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REPORT

INTERIM REPORT

BIOVENTING FIELD INITIATIVE AT JOHNSTON ISLAND FIELD COMMAND DEFENSE NUCLEAR AGENCY, JOHNSTON ATOLL

Department of the Air Force

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INTERIM REPORT
May 14, 1993

FOR

BIOVENTING FIELD INITIATIVE

AT

JOHNSTON ISLAND FIELD COMMAND DEFENSE NUCLEAR AGENCY,
JOHNSTON ATOLL

to

Ms. Catherine M. Vogel
Department of the Air Force
AL/EQ
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by

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INTERIM REPORT

BIOVENTING FIELD INITIATIVE

JOHNSTON ISLAND FIELD COMMAND DEFENSE NUCLEAR AGENCY, JOHNSTON ATOLL

1.0 INTRODUCTION

This report describes the activities conducted at Johnston Island Field Command Defense Nuclear Agency, Johnston Atoll, as part of the Bioventing Field Initiative for the U.S. Air Force Center for Environmental Excellence (AFCEE) and the Environmental Quality Directorate of the Air Force Armstrong Laboratory. This report summarizes the results from the first phase of the study at Johnston Island. First-phase activities include a soil gas survey, air permeability test, in situ respiration test, and installation of bioventing systems. The specific objectives of this Bioventing Field Initiative are described in the following section. Each site at the base is discussed individually, followed by a description of site activities at the background area.

1.1 Objectives

The purpose of this Bioventing Field Initiative is to measure the soil gas permeability and microbial activity at a contaminated site in order to evaluate the potential application of bioventing technology to remediate the site. The specific test objectives are stated below.

- A small-scale soil gas survey will be conducted to identify an appropriate location for installation of the bioventing system. Soil gas from the candidate site should exhibit high total petroleum hydrocarbon (TPH) concentrations, relatively low oxygen concentrations, and relatively high carbon dioxide concentrations. An uncontaminated background location also will be identified.

- The soil gas permeability of the soil and the air vent (well) radius of influence will be determined. To measure these parameters, air will be withdrawn or injected for approximately 8 hours at vent wells located in contaminated soils. Pressure changes will be monitored in an array of monitoring points.

- Immediately following the soil gas permeability test, an in situ respiration test will be conducted. Air will be injected into selected monitoring points to

aerate the soils. The in situ oxygen utilization and carbon dioxide production rates will be measured.

- The data from the soil gas permeability and in situ respiration tests will be used to determine an air injection/withdrawal rate for the bioventing test. A blower will be selected, installed, and operated for 6 to 12 months, and periodic measurements of the soil gas composition will be made to evaluate the long-term effectiveness of bioventing.

1.2 Site Description

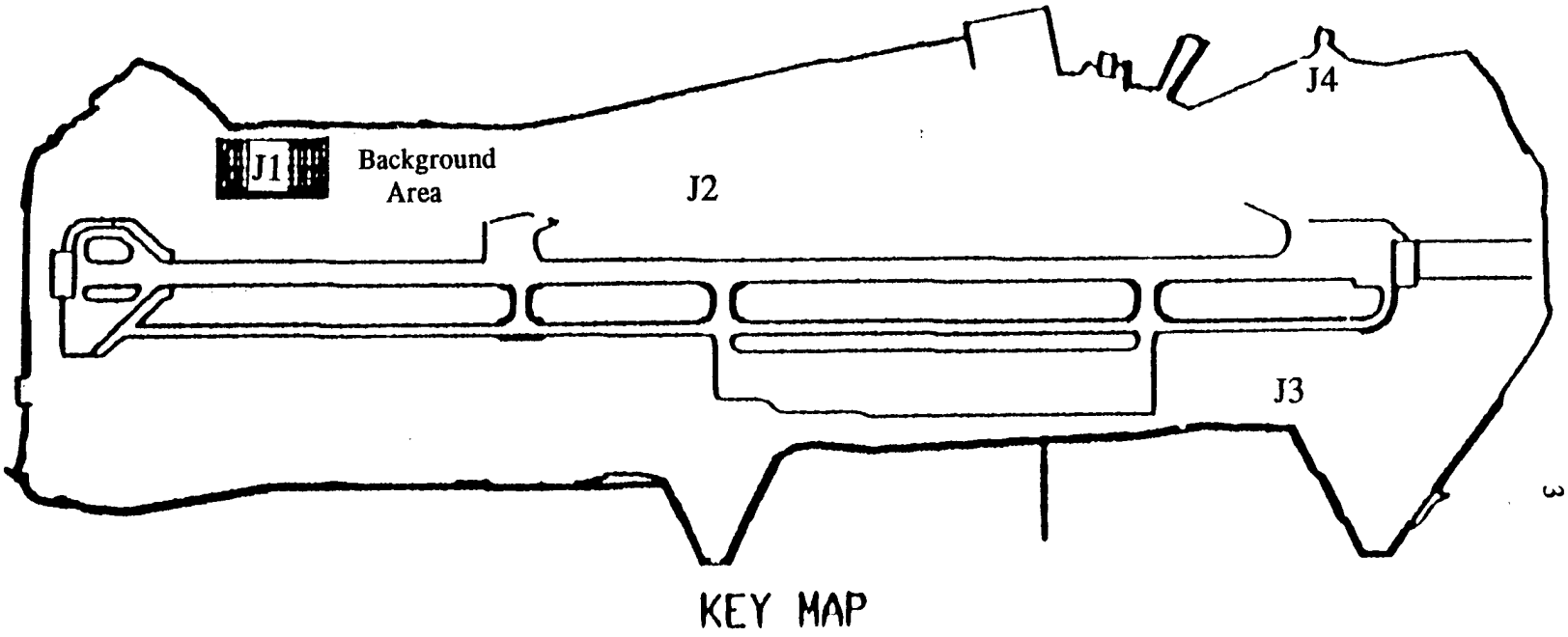
Johnston Atoll is an unincorporated territory of the United States located approximately 717 nautical miles west-southwest of Honolulu, Hawaii. Johnston Island is the largest of the four islands that make up the atoll with an area of approximately 625 acres (Figure 1). The island soils comprised mostly dredged and filled coral from the lagoon. Soil gas surveys were performed at all four sites discussed below by the Air Force environmental contractor, Raytheon Services Nevada, in June of 1992. Summaries of the available data for each site at Johnston Atoll are presented in the following sections. A detailed description is provided in the Test Plan in Appendix A.

1.2.1 Old Fire Training Area (J1)

The Old Fire Training Area is located adjacent to the Johnston Atoll waste storage area. A schematic diagram of the site is shown in Figure 2. The soil gas survey performed in this area in June of 1992 indicated relatively high soil gas hydrocarbon concentrations and correspondingly low oxygen concentrations.

1.2.2 Former Petroleum, Oil, and Lubricants (POL) Tank Farm (J2)

In the 1940s and 1950s, a POL Tank Farm was located in the area west of the site of the base swimming pool. A schematic diagram of the site is shown in Figure 3. Past spills and leaks in this area have resulted in petroleum hydrocarbon contamination in the area. The soil gas survey performed in this area in June of 1992 indicated soil gas hydrocarbon concentrations as high as 30,000 ppm and oxygen concentrations as low as 1%.



J1 = Old Fire Training Area
J2 = Former POL Tank Farm
J3 = Storage Tanks 260 and 261 Site
J4 = Storage Tank 49 Site

Figure 1. Schematic Diagram of Johnston Island Field Command Defense Nuclear Agency, Johnston Atoll

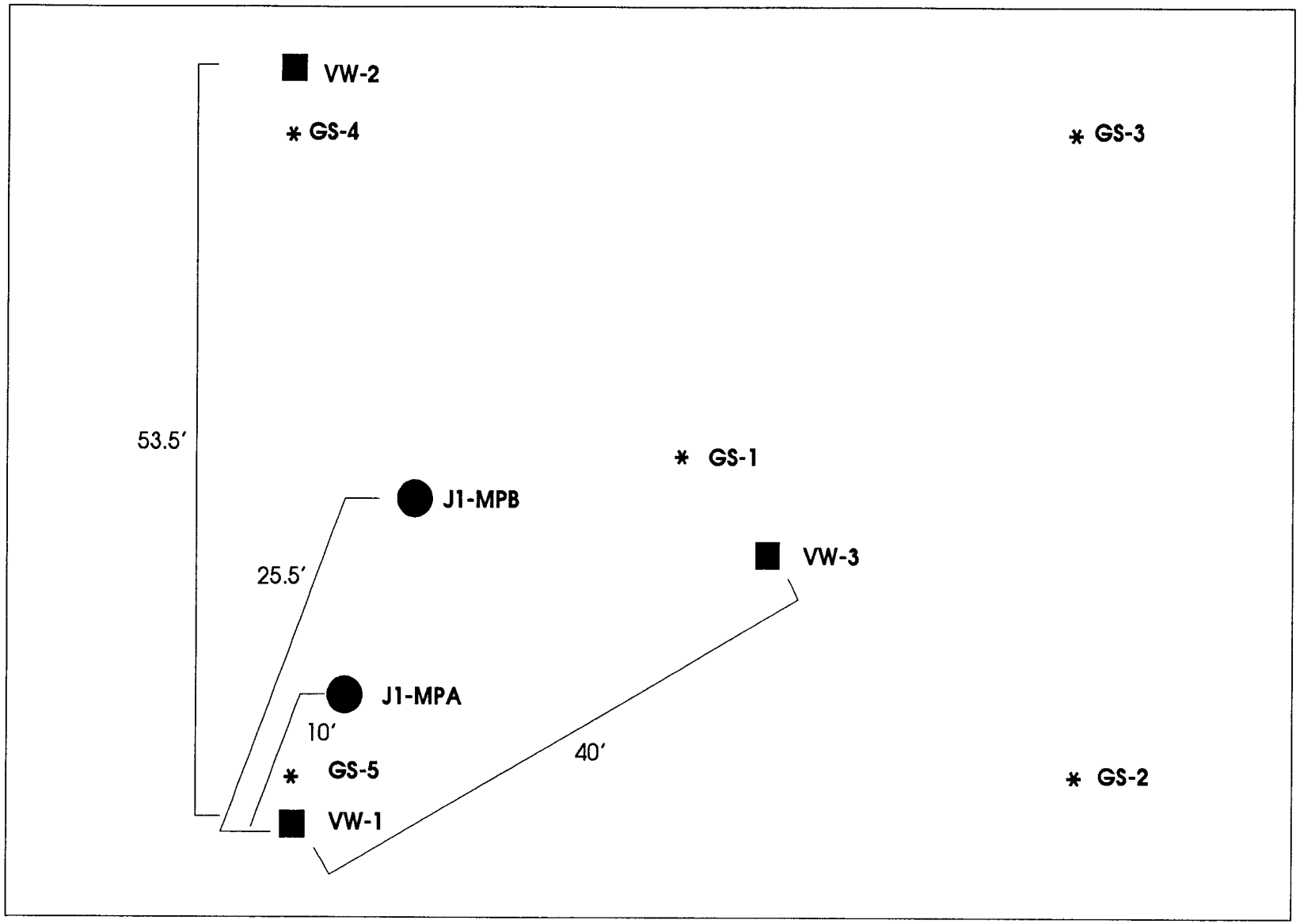


Figure 2. Schematic Diagram of the Old Fire Training Area (GS - Soil Gas Survey Point; MP - Monitoring Point)

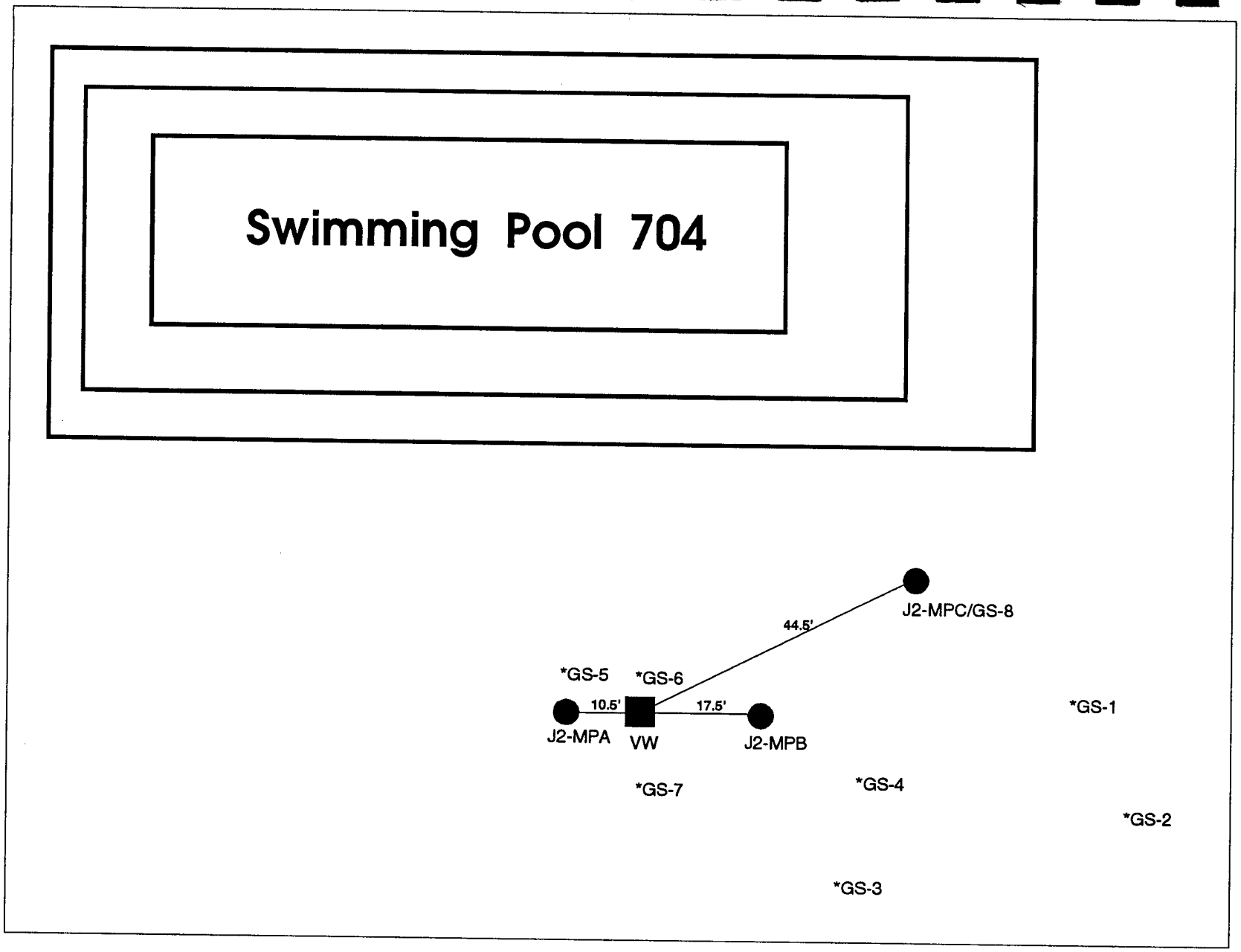


Figure 3. Schematic Diagram of the Former POL Tank Farm (GS - Soil Gas Survey Point; MP - Monitoring Point)

1.2.3 Storage Tanks 260 and 261 Site (J3)

Storage Tanks 260 and 261 are located in the currently used POL Tank Farm at the base. A schematic diagram of the site is shown in Figure 4. Each tank has an approximate capacity of 557,000 gallons of JP-5 fuel. Past spills of JP-5 jet fuel are known to have occurred here. Soil gas hydrocarbon concentrations in excess of 5,000 ppm have been detected in the vicinity of Tank 261. Soil gas oxygen concentrations as low as 5% have been detected in the POL Tank Farm area.

1.2.4 Storage Tank 49 Site (J4)

Storage Tank 49 is a 557,000-gallon aboveground diesel fuel tank located just west of the Johnston Island power plant. A schematic diagram of the site is shown in Figure 5. Soil gas analytical data for the Tank 49 area indicated petroleum hydrocarbon concentrations as high as 340 ppm, oxygen concentrations as low as 2%, and carbon dioxide concentrations as high as 12%.

2.0 OLD FIRE TRAINING AREA

2.1 Chronology of Events and Site Activities

2.1.1 Groundwater Measurements

Groundwater monitoring wells were not present at the Old Fire Training Area. Groundwater was measured at the three vent wells described in Section 2.1.3. Groundwater was measured at 8.75 feet (J1-VW-1), 8.65 feet (J1-VW-2), and 8.7 feet (J1-VW-3). Groundwater level at the site may fluctuate as much as 2 feet due to tidal influence.

2.1.2 Soil Gas Survey

A suitable site for the bioventing demonstration should have soil gas characteristics of high TPH, low oxygen, and high carbon dioxide concentrations. This composition of soil gas would

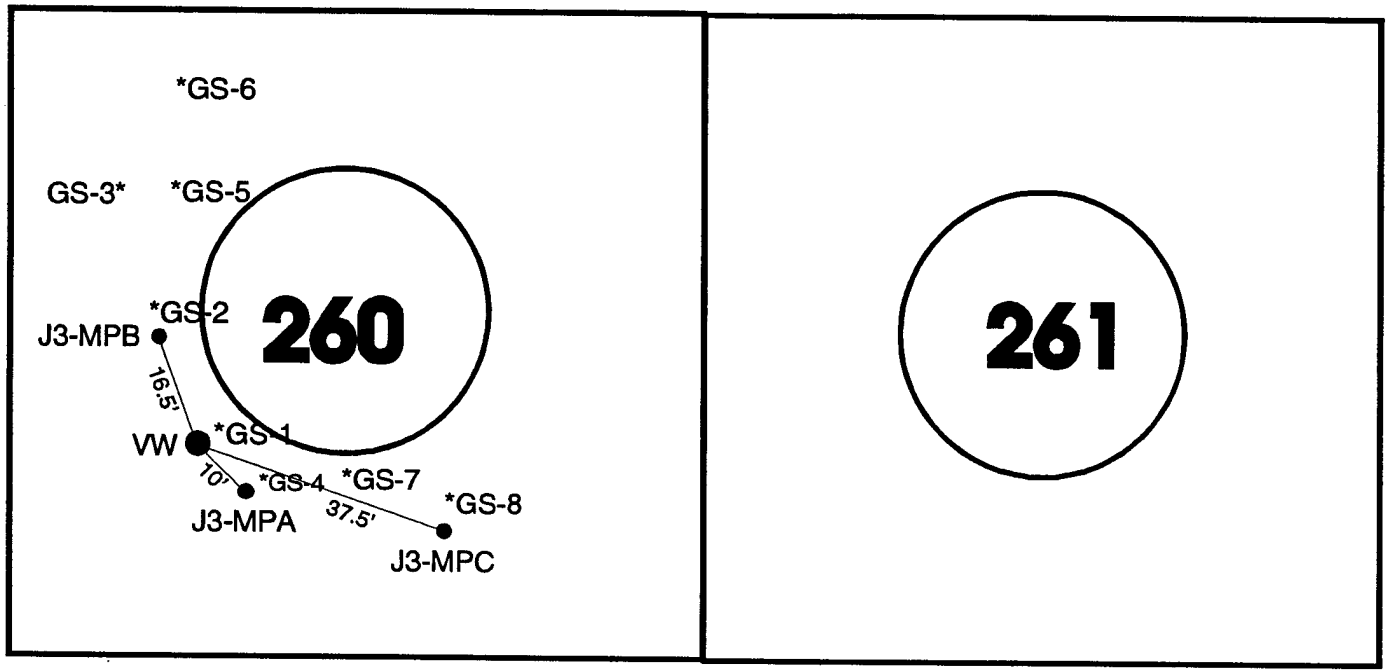


Figure 4. Schematic Diagram of the Storage Tanks 260 and 261 Site (GS - Soil Gas Survey Point; MP - Monitoring Point)

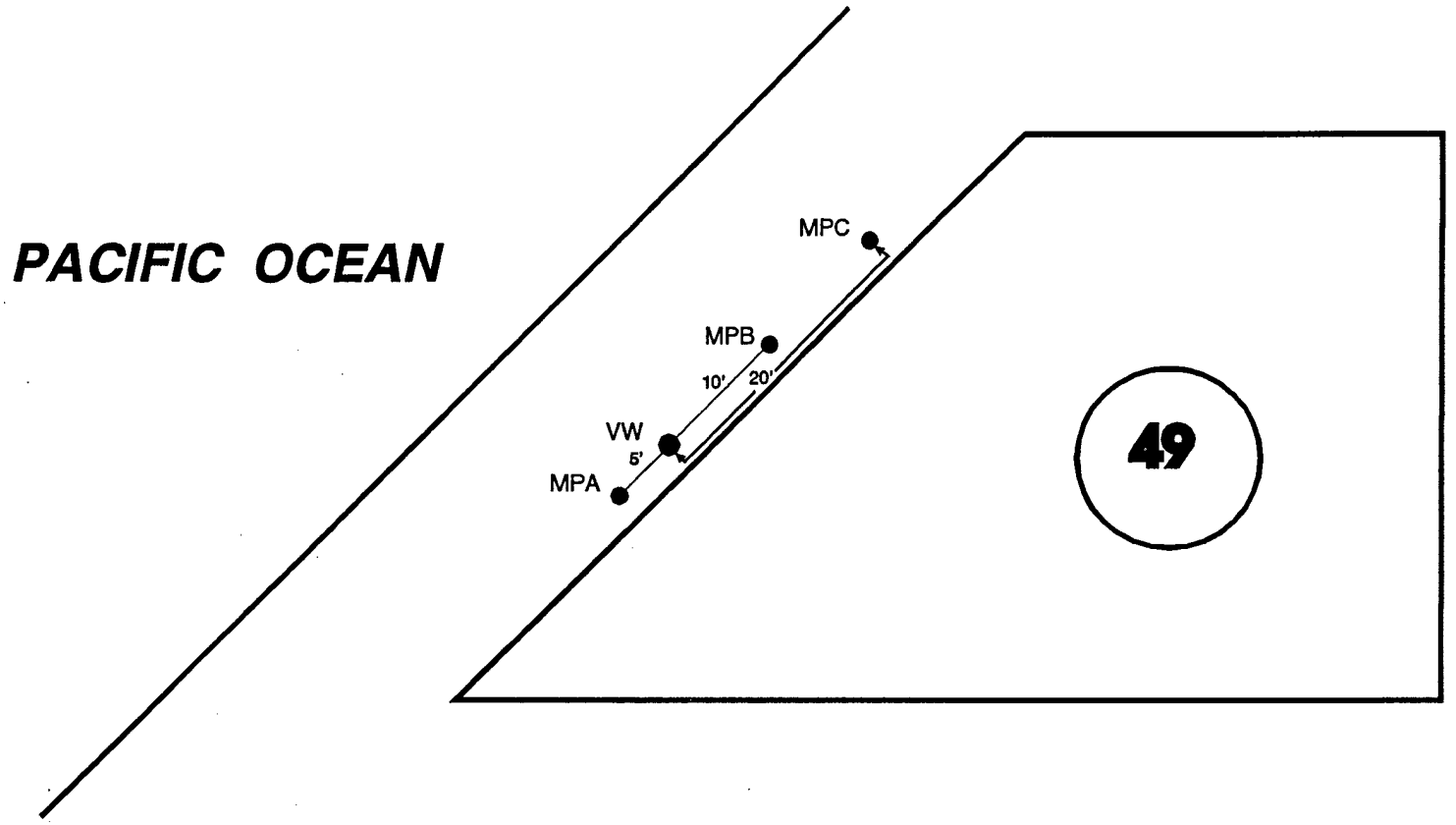


Figure 5. Schematic Diagram of the Tank 49 Site (MP - Monitoring Point)

indicate that oxygen-limiting conditions for microbial activity are present and that the introduction of air may enhance biodegradation of TPH.

On February 20, 1993, a limited soil gas survey was conducted at the Old Fire Training Area. Soil gases were sampled by driving a ⅝-inch-diameter stainless steel probe into the soil with a hammer drill. Soil gas was withdrawn with a vacuum pump and analyzed for oxygen, carbon dioxide, and TPH.

Measurements of oxygen and carbon dioxide in the soil gas were made with a GasTech Model 32520X with oxygen and carbon dioxide ranges of 0 to 25%. The analyzer was calibrated daily against atmospheric oxygen, atmospheric carbon dioxide, a 10% oxygen calibration standard, and a 5% carbon dioxide calibration standard. TPH was measured with a GasTech Trace Techtor with TPH ranges from 0 to 100, 0 to 1,000, and 0 to 10,000 ppm. The GasTech Trace Techtor was calibrated daily against a 4,200-ppm hexane standard.

The soil gas probes were driven to depths of 2.5 feet at several locations in the area. Table 1 provides the initial concentrations of oxygen, carbon dioxide, and TPH for the various locations. Oxygen concentrations varied from 2.5 to 12.6%, and TPH concentrations ranged from 116 to 1,420 ppm. The oxygen results indicate that some areas at this site are oxygen-limited and may respond to bioventing.

2.1.3 Vent Well, Monitoring Point, and Thermocouple Installation

On February 20, 1993, three vent wells and two monitoring points were installed at the Old Fire Training Area, and soil samples were collected for analyses. The vent wells (VW) and monitoring points (MP) were labeled as follows: J1-VW-1, J1-VW-2, J1-VW-3, J1-MPA, and J1-MPB. The locations of the vent well and monitoring points are shown in Figure 2. A cross section of the vent well and monitoring points showing site lithology and construction detail is shown in Figure 6.

The vent wells were installed at a depth of 8.0 feet into an 8-inch-diameter borehole. The vent well consisted of Schedule 40 2-inch-diameter polyvinyl chloride (PVC) piping with 4.5 feet of ten-slot screen. The annular space corresponding to the screened area of the well was filled with silica sand, and the annular space above the screened interval was filled with bentonite to prevent short-circuiting of air to or from the surface.

Table 1. Initial Soil Gas Composition at the Old Fire Training Area

Monitoring Point	Depth (ft)	Oxygen (%)	Carbon Dioxide (%)	TPH (ppm)
GS-1	2.5	3.1	14.0	1,420
GS-2	2.5	5.6	14.9	220
GS-3	2.5	12.6	7.9	116
GS-4	2.5	2.5	14.2	920
GS-5	2.5	3.3	12.0	146

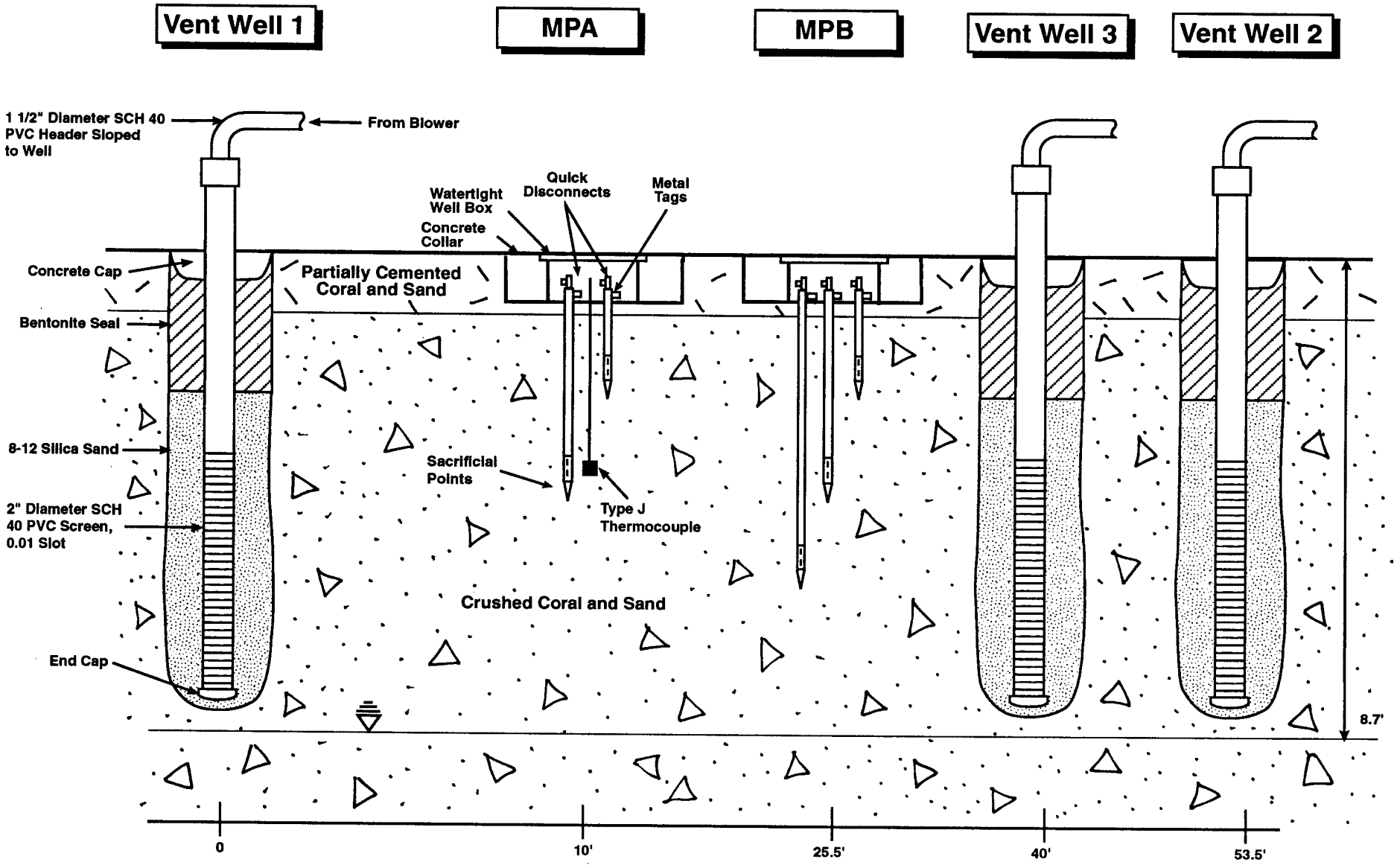


Figure 6. Cross Section of Vent Wells and Monitoring Points at the Old Fire Training Area Showing Site Lithology and Construction Detail (not to scale)

Soil gas monitoring points were sacrificial points which consisted of ¼-inch tubing with an aluminum, 4-inch screened area. The sacrificial points were driven into the soil using a hammer drill. No soil borings were created nor was any sand added. A small amount of wetted bentonite was added at the surface. Monitoring point J1-MPA was installed at 2.5 and 4.5 feet, and monitoring point J1-MPB was installed at 2.5, 4.5, and 6.0 feet.

A Type J thermocouple was installed at a depth of 4.0 feet with monitoring point J1-MPA.

2.1.4 Soil and Soil Gas Sampling and Analyses

Soil samples were collected at the Old Fire Training Area at depths of 4.5 to 5.0 feet and 5.0 to 5.5 feet from the vent well (VW-1) borehole and were labeled J1-VW1-4.5′-5.0′ and J1-VW1-5.0′-5.5′, respectively. The samples were sent under chain of custody to Engineering-Science, Inc., Berkeley Laboratory for analyses of benzene, toluene, ethylbenzene, and xylenes (BTEX); TPH; alkalinity; moisture content; pH; iron; total phosphorous; total Kjeldahl nitrogen; and particle size.

Soil gas samples were collected from monitoring points J1-MPA and J1-MPB, and were labeled J1-MPA-2.5′, J1-MPA-4.5′, and J1-MPB-4.5′. These samples were sent under chain of custody to Air Toxics, Ltd., in Rancho Cordova, California, for analyses of BTEX and TPH.

2.1.5 Soil Gas Permeability and Radius of Influence

A detailed description of the method for conducting a soil gas permeability test, including equations to compute k, the soil gas permeability, is given in the Test Plan and Technical Protocol (Hinchee et al., 1992).

At the Old Fire Training Area, air was injected with a portable 1-horsepower (HP) explosion-proof positive displacement blower unit. After air injection was initiated, pressure readings were taken approximately every 1 to 2 minutes for the first hour, then approximately every 10 minutes for the following hour. Because the pressure measured at the monitoring points reached steady-state rapidly, the steady-state method for determining soil gas permeability was used.

2.1.6 In Situ Respiration Test

Air containing approximately 1% helium was injected into the soil at the Old Fire Training Area for approximately 24 hours, beginning on February 22. Air was injected concurrently into the background monitoring well to measure the natural biodegradation of organic material in the soil. The setup for the in situ respiration test is described by the Test Plan and Technical Protocol (Hinchee et al., 1992). The pump used for air injection was a ½-HP diaphragm pump. Air and helium were injected through the following monitoring points at the depths indicated: J1-MPA-2.5′; J1-MPA-4.5′; and J1-MPB-4.5′. In addition, a temporary monitoring point was installed at a depth of 4.5 feet for use during the in situ respiration test. This monitoring point was labeled J1-MPT-4.5′. After the air/helium injection was turned off, the respiration gases were monitored periodically. The respiration test was terminated on February 26.

Helium concentrations were measured during the in situ respiration test to quantify helium leakage to or from the surface around the monitoring points. Helium loss over time is attributed to either diffusion or leakage. A rapid drop in helium concentration followed by a leveling is an indication of leakage. A gradual loss along with an apparent first-order curve is an indicator of diffusion. As a rough estimate, the diffusion of gas molecules is inversely proportional to the square root of the molecular weight of the gas. Based on molecular weights of 4 for helium and 32 for oxygen, helium gas diffuses about 2.8 times faster than oxygen, or the diffusion of oxygen is 0.35 times the rate of helium diffusion. As a general rule, we have found that if helium concentrations are at least 50 to 60% of the initial levels at test completion, measured oxygen uptake rates are representative. Greater helium loss indicates a problem, and oxygen utilization rates are not considered representative.

To compare data from one site to another, a stoichiometric relationship of the oxidation of the hydrocarbon was assumed. Hexane was used as the representative hydrocarbon for the organic contaminant. The stoichiometric relationship is given by:

$$C_6H_{14} + 9.5O_2 \rightarrow 6CO_2 + 7H_2O \qquad (1)$$

Based on the utilization rates (% per day), the biodegradation rates in terms of mg as a hexane equivalent per kg of soil per day were computed using the equation below by assuming a soil porosity of 0.3 and a bulk density of 1,440 kg/m^3.

$$K_\beta = \frac{-K_o A D_o C}{100} \quad (2)$$

where: K_β = biodegradation rate (mg/kg/day)

K_o = oxygen utilization rate (percent per day)

A = volume of air/kg of soil, in this case 300/1,440 = 0.21

D_o = density of oxygen gas (mg/L), assumed to be 1,330 mg/L

C = mass ratio of hydrocarbon to oxygen required for mineralization, assumed to be 1/3.5 from the above stoichiometric equation.

2.2 Results and Discussion

2.2.1 Soil and Soil Gas Analyses

Results of the soil analyses for BTEX and TPH at the Old Fire Training Area are presented in Table 2. The analytical report for this site is presented in Appendix B. Concentrations of the BTEX compounds in soil samples ranged from below the detection limit for all compounds up to 0.90 mg/kg (toluene), and TPH concentrations ranged from 5,300 to 10,000 mg/kg. The soil gas analyses also showed similar measurements of BTEX and TPH, with concentrations of TPH ranging from below the detection limit (benzene and toluene) up to 5.2 ppmv (total xylenes) (Table 2). The results of the soil chemistry analyses are summarized in Table 3.

2.2.2 Soil Gas Permeability and Radius of Influence

The raw data for the soil gas permeability test at the Old Fire Training Area are presented in Appendix C. Using the steady-state method for calculating soil gas permeability, a soil gas permeability of 3.4 darcys was determined.

Typically, the radius of influence is determined by plotting the log of the pressure change at a specific monitoring point versus the distance from the vent well (Figure 7). The radius of influence is that point at which 1 inch of water pressure can be measured. However, at this site, 1 inch of

Table 2. Results From Soil and Soil Gas Analyses for BTEX and TPH at the Old Fire Training Area

Matrix	Sample Name	Benzene (mg/kg)	Toluene (mg/kg)	Ethylbenzene (mg/kg)	Total Xylenes (mg/kg)	TPH[1] (mg/kg)
Soil	J1-VW1-4.5'-5.0'	<0.67	<0.79	<0.56	<1.0	10,000
	J1-VW1-5.0'-5.5'	<0.67	0.90	<0.67	<1.0	5,300
Matrix	**Sample Name**	**Benzene (ppmv)**	**Toluene (ppmv)**	**Ethylbenzene (ppmv)**	**Total Xylenes (ppmv)**	**TPH[2] (ppmv)**
Soil Gas	J1-MPA-2.5'	<0.021	0.20	0.90	2.0	510
	J1-MPA-4.5'	<0.022	<0.022	0.46	1.2	330
	J1-MPB-4.5'	<0.053	1.2	1.5	5.2	510

[1] Referenced to a reference oil composed of a mixture of 2,2,4-trimethylpentane, *n*-hexadecane, and chlorobenzene.

[2] TPH referenced to gasoline (molecular weight = 100).

Table 3. Results From Soil Chemistry Analyses at the Old Fire Training Area

Parameter	Sample Name	
	J1-VW1-4.5'-5.0'	J1-VW1-5.0'-5.5'
Alkalinity (mg/kg $CaCO_3$)	670	410
Moisture (% by weight)	10.7	11.3
pH	8.9	8.9
Iron (mg/kg)	225	317
Total Phosphorous (mg/kg)	330	410
Total Kjeldahl Nitrogen (mg/kg)	440	440
Particle Size Analysis (%)	Gravel: 37	Gravel: 51
	Sand: 50	Sand: 42
	Silt: 8	Silt: 5
	Clay: 5	Clay: 2

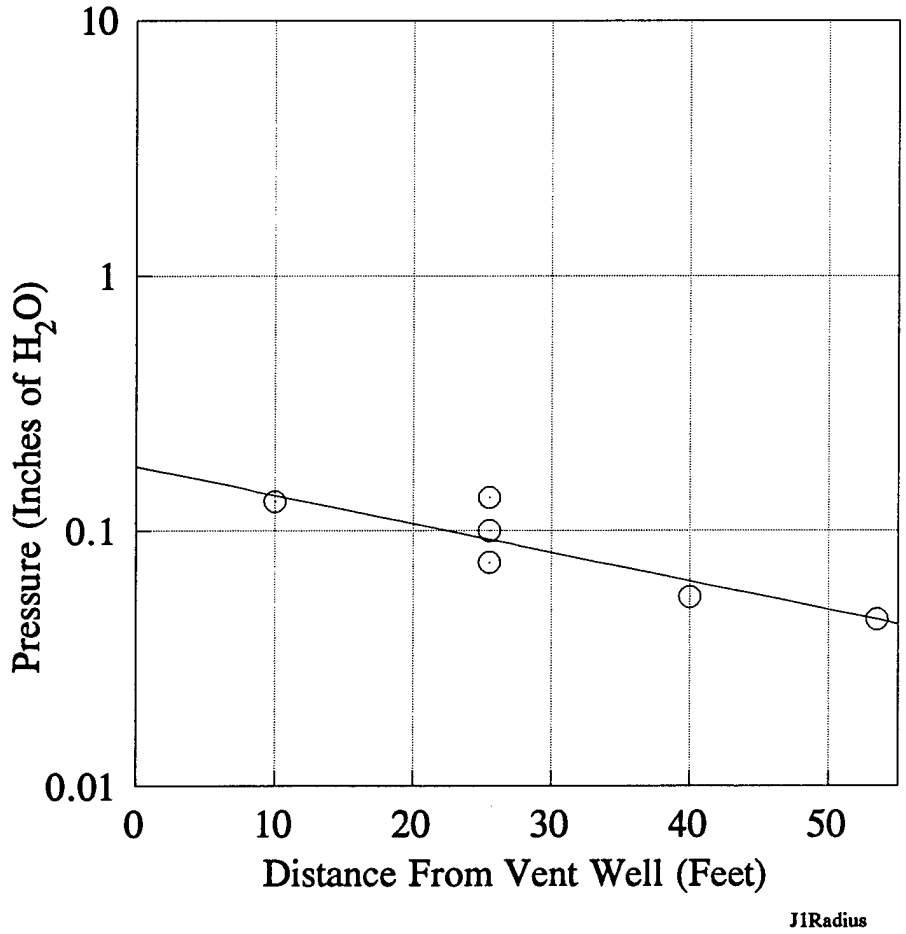


Figure 7. Radius of Influence at the Old Fire Training Area

water pressure was not achieved at any of the monitoring points. Soil gas monitoring during the test, though, showed increased oxygen levels at least 30 feet from the vent well. These levels indicated that pressure change was not the best method for calculating the radius of influence at this site, because soil was oxygenated even without a large pressure change.

2.2.3 In Situ Respiration Test

The results of the in situ respiration test for the Old Fire Training Area are presented in Appendix D. Each figure in Appendix D illustrates the oxygen, carbon dioxide, and helium concentrations as a function of time. An example of typical oxygen utilization at this site is shown in Figure 8, where oxygen utilization and carbon dioxide production at monitoring point J1-MPA-2.5′ are illustrated. A summary of the oxygen utilization and carbon dioxide production rates and corresponding biodegradation rates is shown in Table 4. The biodegradation rates measured at this site were fairly high, with rates ranging from 5.4 to 15 mg/kg/day based on oxygen utilization, and from 2.3 to 6.2 mg/kg/day based on carbon dioxide production.

Loss of helium was insignificant at all monitoring points except at J1-MPT-4.5′, indicating that the monitoring points were well sealed and that the oxygen depletion observed was a result of biodegradation. Helium loss at J1-MPT-4.5′ was rapid enough that some leakage may have occurred.

Soil temperatures were measured during the in situ respiration test. Temperatures during the test ranged from 24.9°C to 26.0°C.

2.2.4 Bioventing Demonstration

The decision was made to install a bioventing system at the Old Fire Training Area. We are currently waiting for power to be installed at the site in order to initiate bioventing.

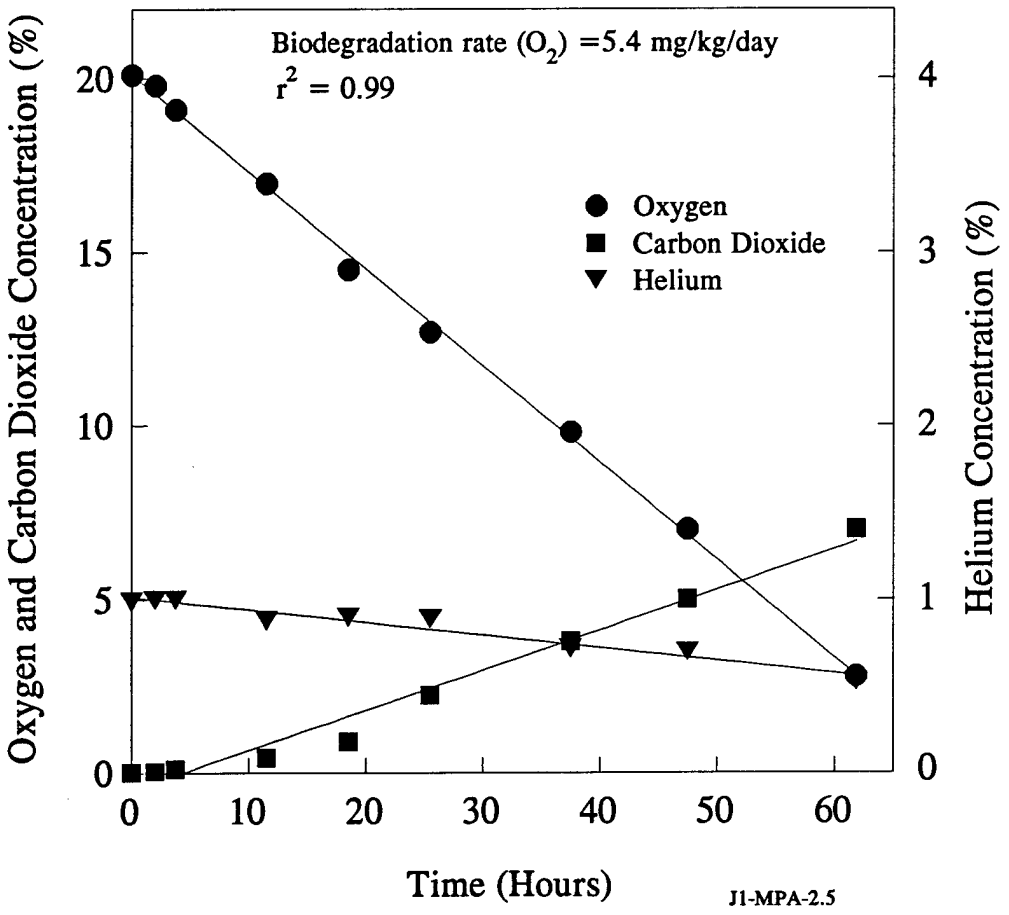


Figure 8. Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point J1-MPA-2.5′ at the Old Fire Training Area

Table 4. Oxygen Utilization and Carbon Dioxide Production Rates During the In Situ Respiration Test at the Old Fire Training Area

Sample Name	Oxygen Utilization Rate (%/hour)	Biodegradation Rate (mg/kg/day)	Carbon Dioxide Production Rate (%/hour)	Biodegradation Rate (mg/kg/day)
Background	0.0074	0.14	0.0017	0.037
J1-MPA-2.5′	0.28	5.4	0.12	4.5
J1-MPA-4.5′	0.35	6.7	0.17	3.6
J1-MPB-4.5′	0.28	5.4	0.11	2.3
J1-MPT-4.5′	0.78	15	0.29	6.2

3.0 FORMER POL TANK FARM

3.1 Chronology of Events and Site Activities

3.1.1 Groundwater Measurements

There were no existing groundwater monitoring wells at the Former POL Tank Farm. Groundwater was recorded at the vent well described in Section 3.1.3 at a depth of 5.5 feet. Groundwater levels at the site may fluctuate as much as 2 feet due to tidal influence.

3.1.2 Soil Gas Survey

On February 20, 1993, a limited soil gas survey was conducted to locate a suitable test area at the Former POL Tank Farm. Soil gases were sampled by driving a ⅝-inch-diameter stainless steel probe into the soil with a hammer drill. Soil gas was withdrawn with a vacuum pump and analyzed for oxygen, carbon dioxide, and TPH. Soil gas measurements were taken as described in Section 2.1.2.

The soil gas probes were driven to depths ranging from 2.5 to 5.0 feet at several locations at the Former POL Tank Farm. Table 5 provides the initial concentrations of oxygen, carbon dioxide, and TPH for the various locations. Relatively low concentrations of oxygen were found at some of the soil gas probes, with concentrations ranging from 1.0 to 13.2%. Relatively high concentrations of carbon dioxide (2.2 to 16.2%) and TPH (88 to 1,600 ppm) were encountered. The low concentrations of oxygen indicate that some areas at this site may respond to bioventing.

3.1.3 Vent Well, Monitoring Point, and Thermocouple Installation

On February 21, 1993, one vent well and three monitoring points were installed at the Former POL Tank Farm, and soil samples were collected for analyses. The monitoring points were labeled J2-MPA, J2-MPB, and J2-MPC. The locations of the vent well and monitoring points are shown in Figure 3. A cross section of the vent well and monitoring points showing site lithology and construction detail is shown in Figure 9.

Table 5. Initial Soil Gas Composition at the Former POL Tank Farm

Monitoring Point	Depth (ft)	Oxygen (%)	Carbon Dioxide (%)	TPH (ppm)
GS-1	2.5	13.2	>5.0	NM
	5.0	13.0	>5.0	NM
GS-2	2.5	12.5	>5.0	NM
GS-3	2.5	13.0	>5.0	NM
GS-4	2.5	13.0	>5.0	NM
	5.0	13.2	>5.0	NM
GS-5	2.5	12.0	8.0	120
GS-6	2.5	1.0	15.8	1,600
GS-7	2.5	2.0	2.2	88
GS-8	2.5	1.5	16.2	1,000

NM Not measured.

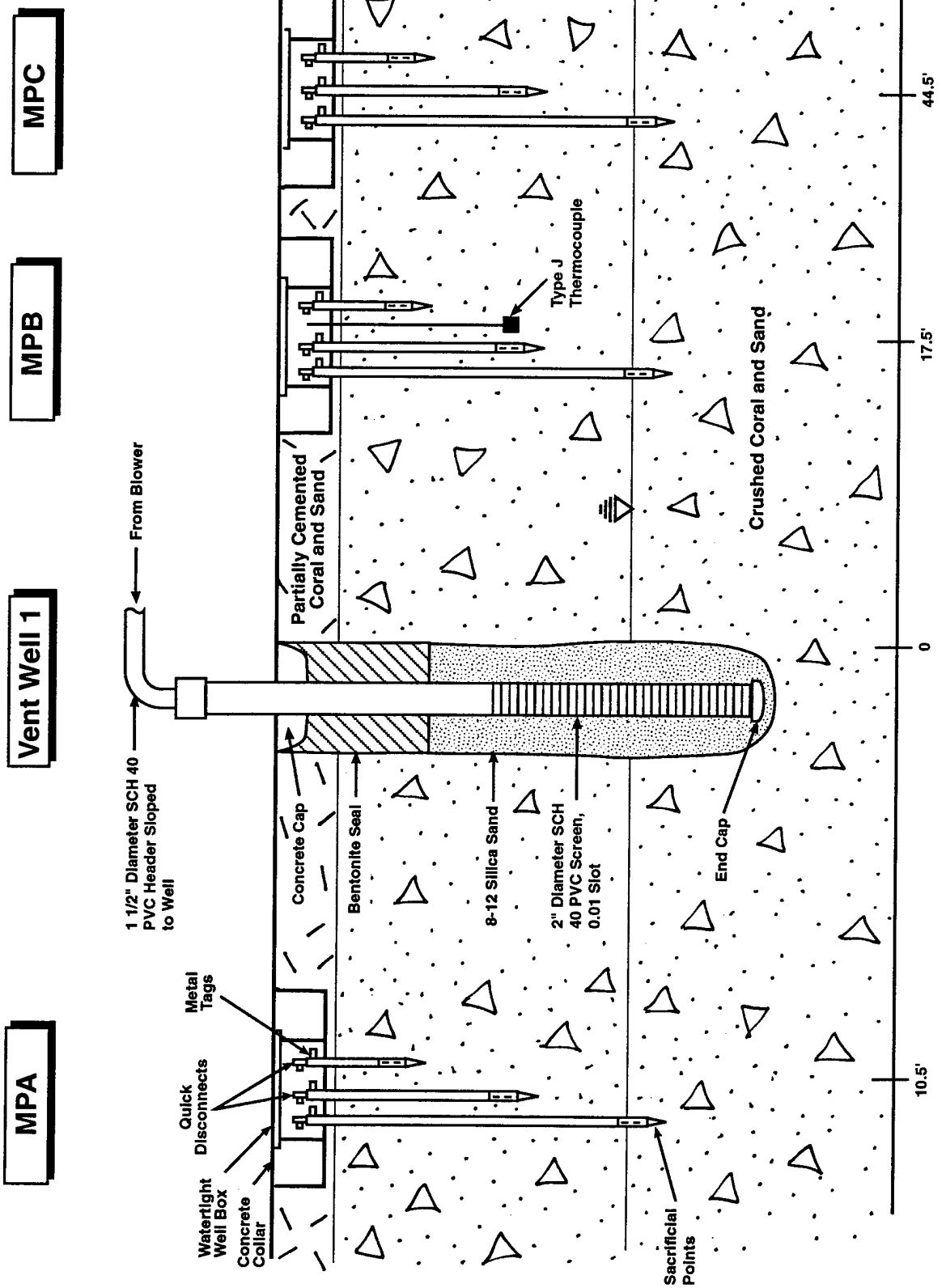


Figure 9. Cross Section of Vent Well and Monitoring Points at the Former POL Tank Farm Showing Site Lithology and Construction Detail (not to scale)

F/Lesson12

The vent well was installed at a depth of 8.0 feet into an 8-inch-diameter borehole. The vent well consisted of Schedule 40 2-inch-diameter PVC piping with 4.5 feet of ten-slot screen. The annular space corresponding to the screened area of the well was filled with silica sand, whereas the annular space above the screened interval was filled with bentonite to prevent short-circuiting of air to or from the surface.

Soil gas monitoring points were sacrificial points consisting of ¼-inch tubing with an aluminum 4-inch screened area. The sacrificial points were driven into the soil with a hammer drill. No soil borings were created, nor was any sand added. A small amount of wetted bentonite was added at the surface. All monitoring points were installed at depths of 2.5, 4.5, and 6.0 feet.

A Type J thermocouple was installed at a depth of 4.0 feet with monitoring point J2-MPB.

3.1.4 Soil and Soil Gas Sampling and Analyses

Soil samples were collected at the Former POL Tank Farm at depths of 4.5 to 5.0 feet and 5.0 to 5.5 feet from the vent well borehole and were labeled J2-VW-4.5′-5.0′ and J2-VW-5.0′-5.5′. The samples were sent under chain of custody to Engineering-Science, Inc., Berkeley Laboratory for analyses of BTEX, TPH, alkalinity, moisture content, pH, iron, total phosphorous, total Kjeldahl nitrogen, and particle size.

Soil gas samples were collected from monitoring points J2-MPA and J2-MPB. These samples were labeled J2-MPA-2.5′, J2-MPA-4.5′, and J2-MPB-4.5′ and were sent under chain of custody to Air Toxics, Ltd., in Rancho Cordova, California, for analyses of BTEX and TPH.

3.1.5 Soil Gas Permeability and Radius of Influence

A detailed description of the method for conducting a soil gas permeability test, including equations to compute k, the soil gas permeability, is presented by the Test Plan and Technical Protocol (Hinchee et al., 1992).

A portable 1-HP explosion-proof positive displacement blower unit was used to inject air at the Former POL Tank Farm. After air injection was initiated, pressure readings were taken approximately every 1 to 2 minutes for the first hour, then approximately every 10 minutes for the following hour. The steady-state method was used to calculate the soil gas permeability.

3.1.6 In Situ Respiration Test

The setup for the in situ respiration test was as described in Section 2.1.6. Air containing approximately 1% helium was injected into the soil at the Former POL Tank Farm for approximately 24 hours, beginning on February 22. The pump used for air injection was a ½-HP diaphragm pump. Air and helium were injected through the following monitoring points at the depths indicated: J2-MPA-2.5′; J2-MPA-4.5′; and J2-MPB-4.5′. After the air/helium injection was turned off, the respiration gases were monitored periodically. The respiration test was terminated on February 26.

3.2 Results and Discussion

3.2.1 Soil and Soil Gas Analyses

Results of the soil analyses for BTEX and TPH at the Former POL Tank Farm are presented in Table 6. The analytical report for this site is presented in Appendix B. Benzene and toluene were at concentrations below the detection limit in soil and soil gas samples, whereas TPH concentrations ranged from 9,300 to 16,800 mg/kg in soil and from 3,400 to 4,400 ppmv in soil gas. The results of the soil chemistry analyses are summarized in Table 7.

3.2.2 Soil Gas Permeability and Radius of Influence

The raw data for the soil gas permeability test at the Former POL Tank Farm are presented in Appendix E. Using the steady-state method, a soil gas permeability of 3.7 darcys was calculated for the site. As discussed in Section 2.2.2, a very small radius of influence was calculated based on pressure change (Figure 10). However, oxygen levels increased at most points, indicating a radius of influence of at least 25 feet.

3.2.3 In Situ Respiration Test

The results of the in situ respiration test for the Former POL Tank Farm are presented in Appendix F. Each figure in Appendix F illustrates the oxygen, carbon dioxide, and helium concentrations as a function of time. An example of typical oxygen utilization at this site is shown in

Table 6. Results From Soil and Soil Gas Analyses for BTEX and TPH at the Former POL Tank Farm

Matrix	Sample Name	Benzene (mg/kg)	Toluene (mg/kg)	Ethylbenzene (mg/kg)	Total Xylenes (mg/kg)	TPH[1] (mg/kg)
Soil	J2-VW-4.5'-5.0'	<1.3	<1.6	3.1	2.5	9,300
	J2-VW-5.0'-5.5'	<3.3	<3.9	3.9	<5.0	16,800
Matrix	**Sample Name**	**Benzene (ppmv)**	**Toluene (ppmv)**	**Ethylbenzene (ppmv)**	**Total Xylenes (ppmv)**	**TPH[2] (ppmv)**
Soil Gas	J2-MPA-2.5'	<0.20	<0.20	2.3	2.3	3,400
	J2-MPA-4.5'	<0.20	<0.20	3.2	2.4	3,700
	J2-MPB-4.5'	<0.26	<0.26	3.6	2.1	4,400

[1] Referenced to a reference oil composed of a mixture of 2,2,4-trimethylpentane, *n*-hexadecane, and chlorobenzene.

[2] TPH referenced to gasoline (molecular weight = 100).

Table 7. Results From Soil Chemistry Analyses at the Former POL Tank Farm

Parameter	Sample Name	
	J2-VW-4.5'-5.0'	J2-VW-5.0'-5.5'
Alkalinity (mg/kg $CaCO_3$)	480	500
Moisture (% by weight)	23.5	22.6
pH	7.7	7.8
Iron (mg/kg)	181	4.8
Total Phosphorous (mg/kg)	750	650
Total Kjeldahl Nitrogen (mg/kg)	700	670
Particle Size Analysis (%)	Gravel: 45	Gravel: 39
	Sand: 44	Sand: 47
	Silt: 6	Silt: 8
	Clay: 5	Clay: 6

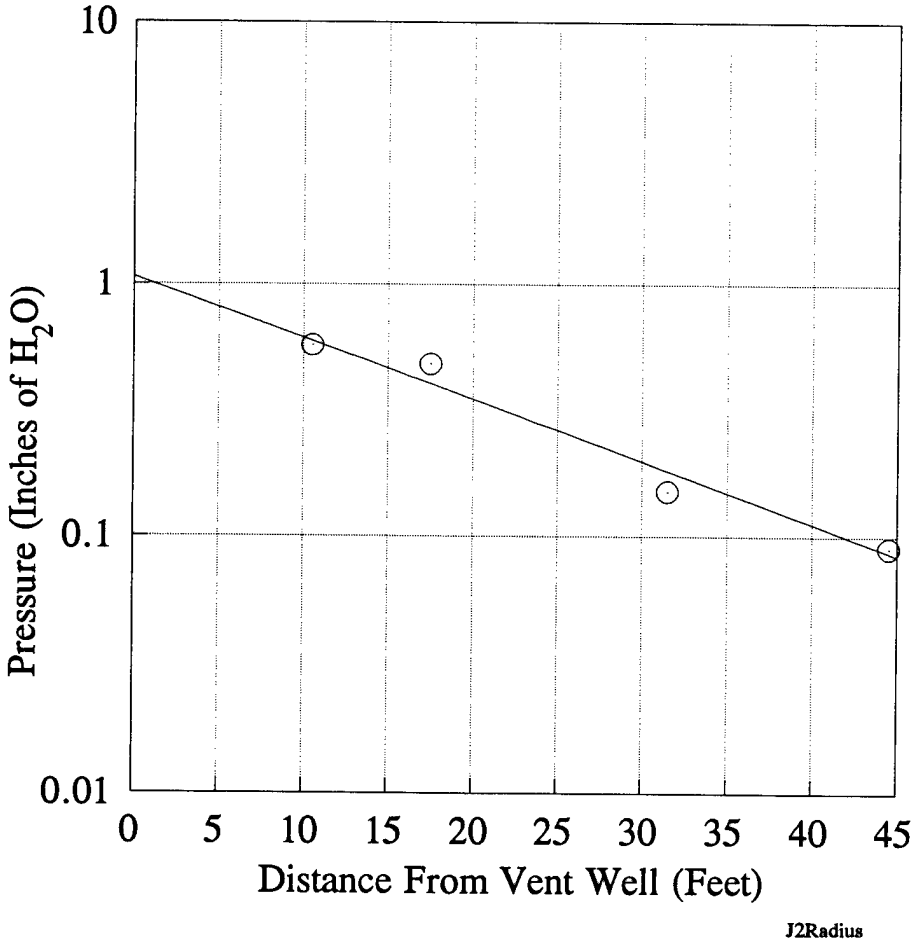


Figure 10. Radius of Influence at the Former POL Tank Farm

Figure 11, where oxygen utilization and carbon dioxide production at monitoring point J2-MPA-2.5′ are illustrated. A summary of the oxygen utilization and carbon dioxide production rates and the corresponding biodegradation rates is shown in Table 8. The biodegradation rates measured at this site were relatively high, with rates ranging from 4.2 to 5.2 mg/kg/day based on oxygen utilization, and from 0.28 to 1.1 mg/kg/day based on carbon dioxide production.

Loss of helium was insignificant at all monitoring points, indicating that the monitoring points were well sealed and that the oxygen depletion observed was a result of biodegradation.

Soil temperatures were not measured during the in situ respiration test because the thermocouple was not installed until after the test.

3.2.4 Bioventing Demonstration

The decision was made to install a bioventing system at the Former POL Tank Farm. The bioventing system was initiated on March 1, 1993, at a flowrate of 40 standard cubic feet per minute (scfm).

Table 8. Oxygen Utilization and Carbon Dioxide Production Rates During the In Situ Respiration Test at the Former POL Tank Farm

Sample Name	Oxygen Utilization Rate (%/hour)	Biodegradation Rate (mg/kg/day)	Carbon Dioxide Production Rate (%/hour)	Biodegradation Rate (mg/kg/day)
Background	0.0074	0.14	0.0017	0.037
J2-MPA-2.5′	0.22	4.3	0.013	0.28
J2-MPA-4.5′	0.22	4.2	0.029	0.63
J2-MPB-4.5′	0.27	5.2	0.050	1.1

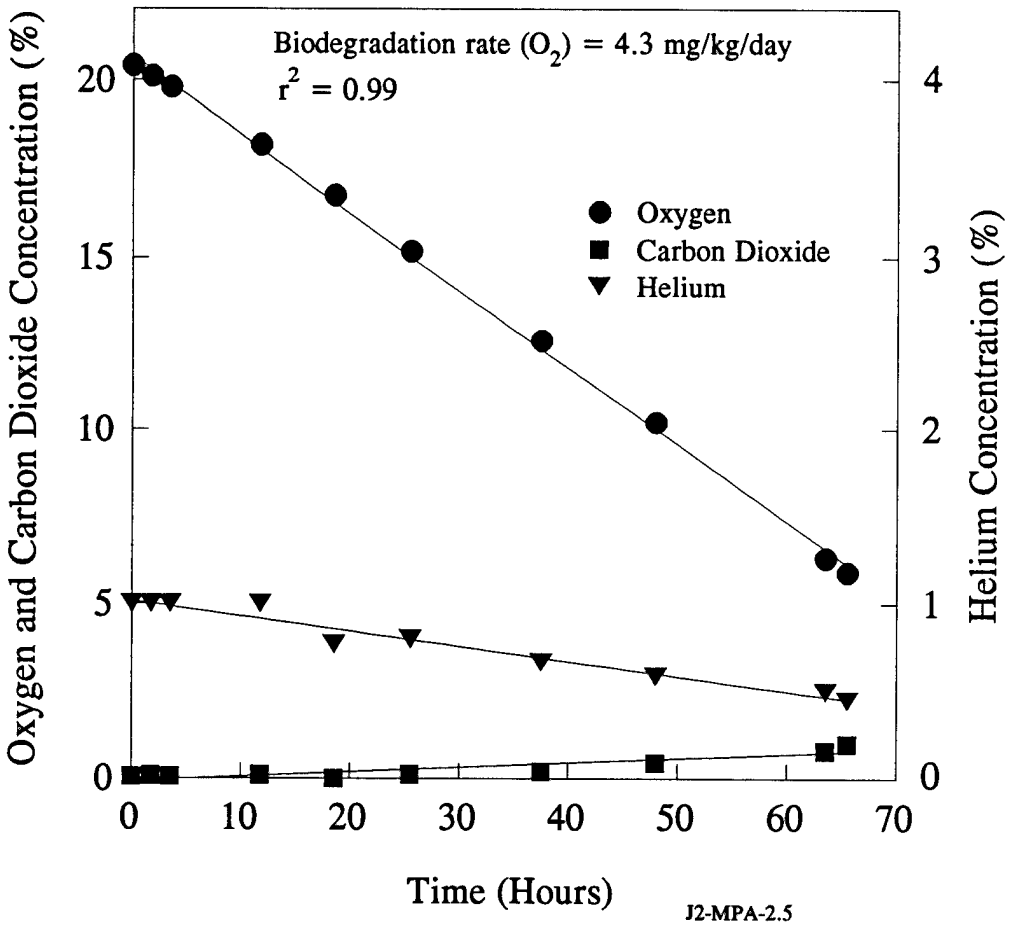


Figure 11. Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point J2-MPA-2.5′ at the Former POL Tank Farm

4.0 STORAGE TANKS 260 AND 261 SITE

4.1 Chronology of Events and Site Activities

4.1.1 Groundwater Measurements

There were no existing groundwater wells at the Storage Tanks 260 and 261 Site. Groundwater was measured at the vent well described in Section 4.1.3 at a depth of 5.5 feet.

4.1.2 Soil Gas Survey

On February 20, 1993, a limited soil gas survey was conducted to locate a suitable test area at the Storage Tanks 260 and 261 Site. Soil gases were sampled by driving a ⅝-inch-diameter stainless steel probe into the soil with a hammer drill. Soil gas was withdrawn with a vacuum pump and analyzed for oxygen, carbon dioxide, and TPH. Soil gas measurements were taken as described in Section 2.1.2.

The soil gas probes were driven to depths ranging from 2.5 to 5.5 feet at several locations. Table 9 provides the initial concentrations of oxygen, carbon dioxide, and TPH for the various locations at the Storage Tanks 260 and 261 Site. Relatively low concentrations of oxygen were found at some of the soil gas probes, with concentrations ranging from 0.5 to 14.0%. Relatively high concentrations of carbon dioxide (4.0 to 16.3%) and TPH (100 to greater than 20,000 ppm) were encountered. The low concentrations of oxygen indicate that some areas at this site may respond to bioventing.

4.1.3 Vent Well, Monitoring Point, and Thermocouple Installation

On February 23, one vent well and three monitoring points were installed at the Storage Tanks 260 and 261 Site. The monitoring points were labeled J3-MPA, J3-MPB, and J3-MPC. The locations of the vent well and monitoring points are shown in Figure 4. A cross section of the vent well and monitoring points showing site lithology and construction detail is shown in Figure 12.

The vent well was installed at a depth of 8.0 feet into an 8-inch-diameter borehole. The vent well consisted of Schedule 40 2-inch-diameter PVC piping with 4.5 feet of ten-slot screen. The annular space corresponding to the screened area of the well was filled with silica sand, whereas the annular space above the screened interval was filled with bentonite to prevent short-circuiting of air to

Table 9. Initial Soil Gas Composition at the Storage Tanks 260 and 261 Site

Monitoring Point	Depth (ft)	Oxygen (%)	Carbon Dioxide (%)	TPH (ppm)
GS-1	2.5	9.0	8.0	100
	3.5	8.4	8.0	106
	4.5	7.9	8.7	112
	5.5	7.5	9.2	166
GS-2	2.5	0.8	13.0	2,300
GS-3	2.5	0.5	12.1	520
GS-4	2.5	2.0	12.3	>20,000
GS-5	2.5	14.0	4.0	NM
GS-6	2.5	4.0	12.0	1,760
GS-7	2.5	4.0	16.3	>20,000
GS-8	2.5	2.0	15.5	9,000
GS-9	2.5	4.4	14.7	4,000

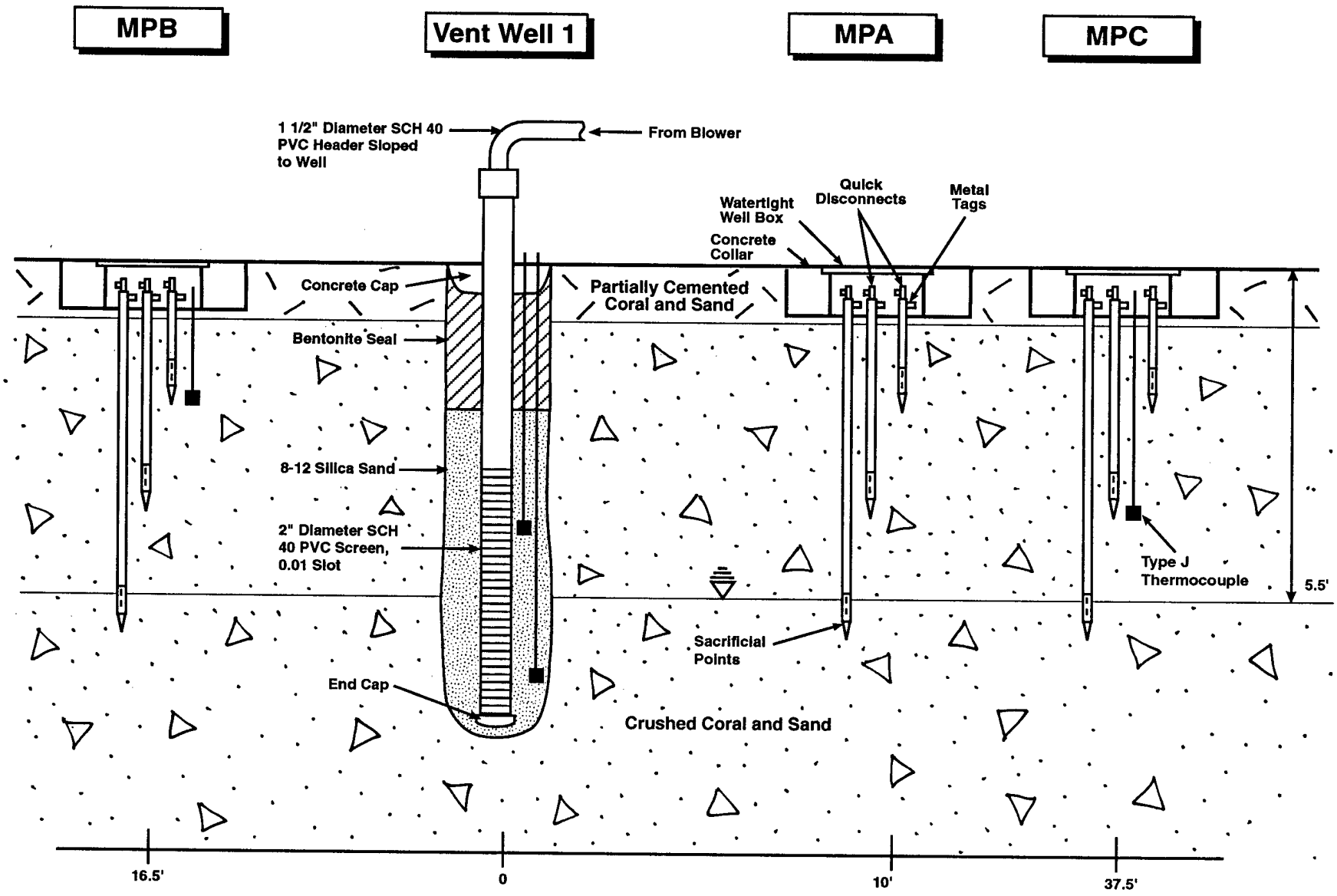


Figure 12. Cross Section of Vent Well and Monitoring Points at the Storage Tanks 260 and 261 Site Showing Site Lithology and Construction Detail (not to scale)

to or from the surface.

Soil gas probes were sacrificial points which consisted of ¼-inch tubing with an aluminum, 4-inch screened area. The sacrificial points were driven into the soil using a hammer drill. No soil borings were created, nor was any sand added. A small amount of wetted bentonite was added at the surface. All monitoring points were installed at depths of 2.5, 4.5, and 6.0 feet.

A Type J thermocouple was installed with monitoring points J3-MPB-2.5′ and J3-MPC-4.5′. In addition, two Type J thermocouples were installed with the vent well at depths of 4.5 and 7.0 feet.

4.1.4 Soil and Soil Gas Sampling and Analyses

Soil samples were collected at the Storage Tanks 260 and 261 Site at depths of 4.0 to 4.5 feet and 4.5 to 5.0 feet from the vent well borehole and were labeled J3-VW-4.0′-4.5′ and J3-VW-4.5′-5.0′, respectively. The samples were sent under chain of custody to Engineering-Science, Inc., Berkeley Laboratory for analyses of BTEX, TPH, alkalinity, moisture content, pH, iron, total phosphorous, total Kjeldahl nitrogen, and particle size.

Soil gas samples were collected from monitoring points J3-MPA, J3-MPB, and J3-MPC, and were labeled J3-MPA-2.5′, J3-MPB-4.5′, J3-MPC-2.5′, and J3-MPC-4.5′. These samples were sent under chain of custody to Air Toxics, Ltd., in Rancho Cordova, California, for analyses of BTEX and TPH.

4.1.5 Soil Gas Permeability and Radius of Influence

A detailed description of the method for conducting a soil gas permeability test, including equations to compute k, the soil gas permeability, is presented by the Test Plan and Technical Protocol (Hinchee et al., 1992).

A portable 1-HP explosion-proof positive displacement blower unit was used to inject air at the Storage Tanks 260 and 261 Site. After air injection was initiated, pressure readings were taken approximately every 1 to 2 minutes for the first hour, then approximately every 10 minutes for the following hour. The steady-state method was used to calculate the soil gas permeability.

4.1.6 In Situ Respiration Test

Air containing approximately 1% helium was injected into the soil at the Storage Tanks 260 and 261 Site for approximately 24 hours, beginning on February 24. The setup for the in situ

Table 11. Results From Soil Chemistry Analyses at the Storage Tanks 260 and 261 Site

Parameter	Sample Name	
	J3-VW-4.0'-4.5'	J3-VW-4.5'-5.0'
Alkalinity (mg/kg $CaCO_3$)	340	370
Moisture (% by weight)	12.4	12.5
pH	8.9	9.1
Iron (mg/kg)	92.7	74.5
Total Phosphorous (mg/kg)	320	360
Total Kjeldahl Nitrogen (mg/kg)	140	140
Particle Size Analysis (%)	Gravel: 29	Gravel: 25
	Sand: 59	Sand: 60
	Silt: 6	Silt: 8
	Clay: 6	Clay: 7

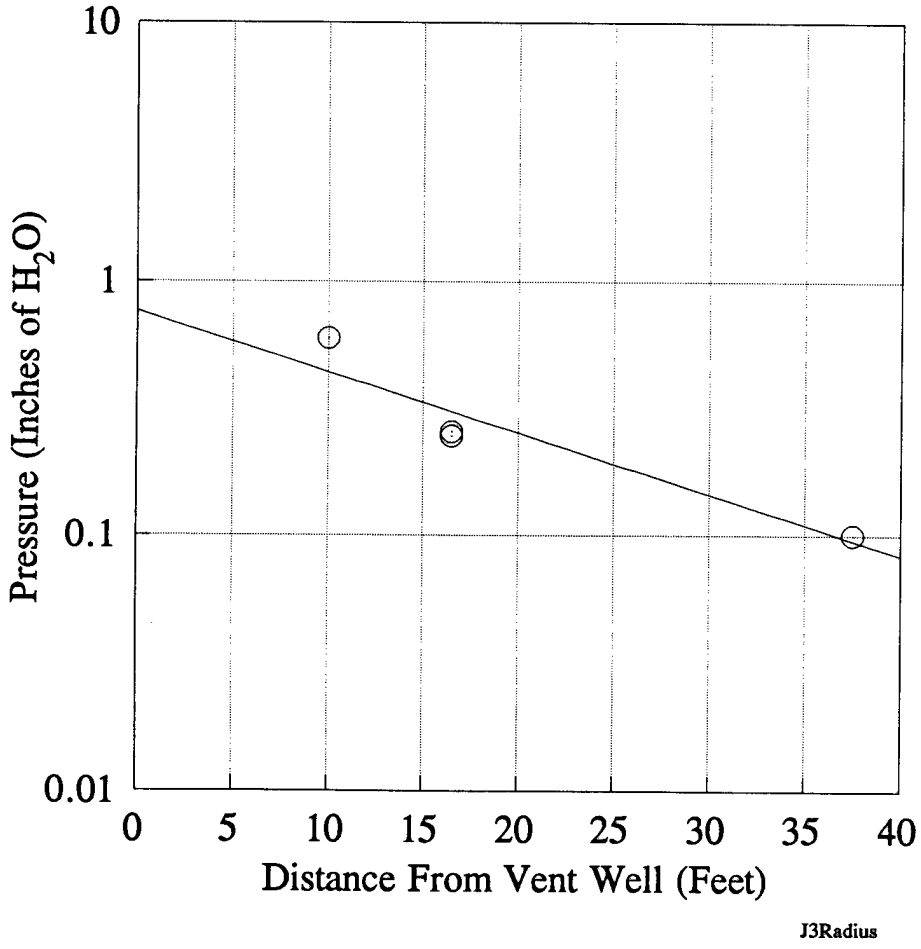


Figure 13. Radius of Influence at the Storage Tanks 260 and 261 Site

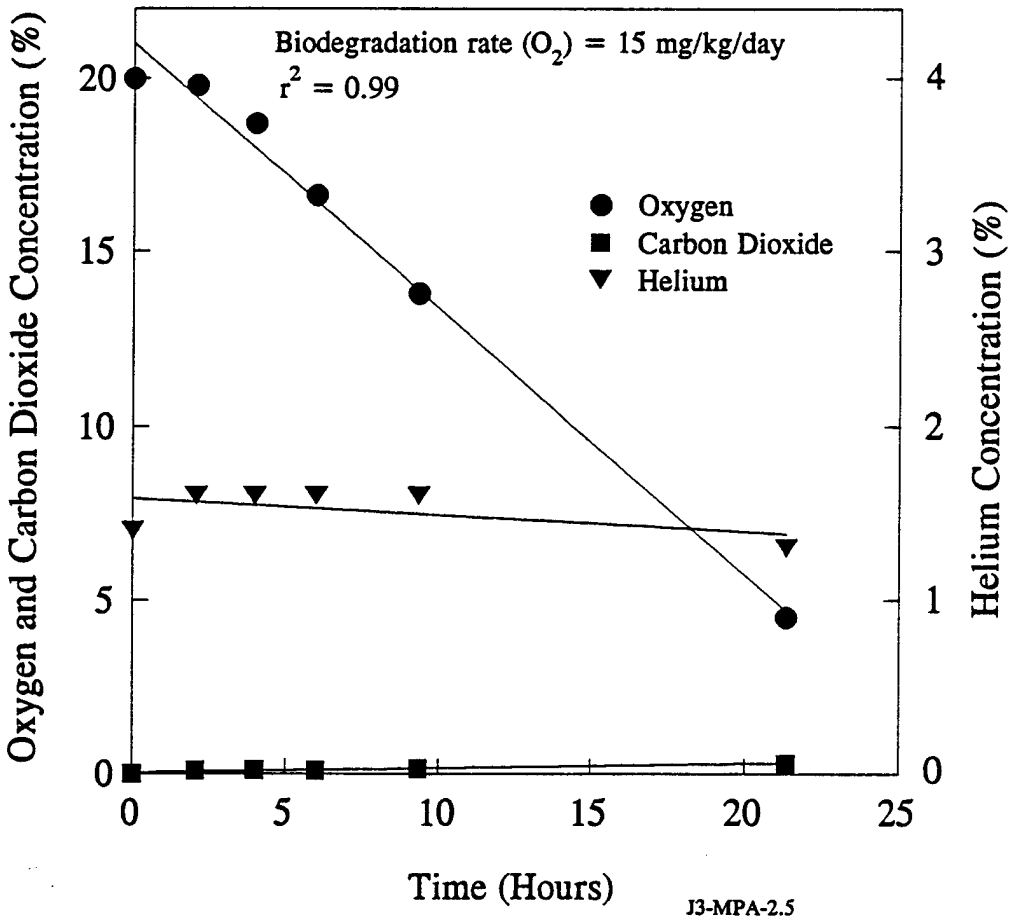


Figure 14. Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point J3-MPA-2.5′ at the Storage Tanks 260 and 261 Site

Table 12. Oxygen Utilization and Carbon Dioxide Production Rates During the In Situ Respiration Test at the Storage Tanks 260 and 261 Site

Sample Name	Oxygen Utilization Rate (%/hour)	Biodegradation Rate (mg/kg/day)	Carbon Dioxide Production (%/hour)	Biodegradation Rate (mg/kg/day)
Background	0.0074	0.014	0.0017	0.037
J3-MPA-2.5′	0.77	15	0.013	0.27
J3-MPB-4.5′	0.98	19	0.15	3.3
J3-MPC-2.5′	0.38	7.3	0.049	1.1
J3-MPC-4.5′	0.44	8.4	0.047	1.0

19 mg/kg/day based on oxygen utilization, and 0.27 to 3.3 mg/kg/day based on carbon dioxide production.

Loss of helium was insignificant at all monitoring points, indicating that the monitoring points were well sealed and that the oxygen depletion observed was a result of biodegradation.

Soil temperatures were measured during the in situ respiration test and ranged from 27.8 to 28.7°C (J3-MPB-2.5), from 23.7 to 26.1°C (J3-MPC-4.5'), and from 27.3 to 30.7°C (vent well - 4.5').

4.2.4 Bioventing Demonstration

The decision was made to install a bioventing system at the Storage Tanks 260 and 261 Site. The bioventing system was initiated in mid-March at a flowrate of 22 scfm.

5.0 STORAGE TANK 49 SITE

To avoid disturbing the free product recovery system in place at the Storage Tank 49 Site, the only activities conducted were to install a 1¼" drive point as a vent well. The vent well was installed to depth of 5.0 feet with 3.0 feet of screen. A 1.5-foot bentonite seal was added at the surface. In addition, three sacrificial points (described previously) were installed at depths of 4.5 feet. The monitoring points were placed 5.0, 10.0, and 20.0 feet away from the vent well and were labeled J4-MPA, J4-MPB, and J4-MPC, respectively.

A wind-powered turbine was attached to the vent well on February 25, 1993, to determine whether this would aerate the soil. Soil gas oxygen concentrations were measured at the three monitoring points over a 3-day period. As shown in Table 13, an increase in oxygen concentration was observed at J4-MPA and a slight increase was observed at monitoring point J4-MPB.

There were no soil or soil gas samples collected at this site for laboratory analyses, nor was an in situ respiration test or an air permeability test conducted.

Table 13. Soil Gas Oxygen Concentrations (%) at the Tank 49 Site

Date	Monitoring Point		
	J4-MPA	J4-MPB	J4-MPC
February 24 Initial	0	0	0
February 25 Immediately after installation of turbine	0	0	0
February 26	0.03	0.05	−0.1
February 27	2.9	0.7	−0.2
February 28	3.0	0.1	−0.2

6.0 BACKGROUND AREA

An uncontaminated background (BG) area was located approximately 120 feet north of the Old Fire Training Area (Figure 1). A vent well was not installed in this area, but a monitoring point was installed at a depth of 4.5 feet. The monitoring point consisted of ¼-inch tubing connected to a 1-inch-diameter by 6-inch-long screened area. A 1.5-foot-thick sand pack was used around the screened area, followed by fill and a 1-foot interval of wetted bentonite. The site lithology at this area was representative of that in the contaminated areas.

Soil samples were collected at depths of 4.5 to 5.0 feet, and 5.0 to 5.5 feet, 5.5 to 6.0, and 6.0 to 6.5 feet from the borehole and were labeled J-BG-4.5′-5.0′, J-BG-5.0′-5.5′, J-BG-5.5′-6.0′, and J-BG-6.0′-6.5′, respectively. The samples were sent under chain of custody to Engineering-Science, Inc., Berkeley Laboratory for analyses of BTEX, TPH, alkalinity, moisture content, pH, iron, total phosphorous, total Kjeldahl nitrogen, and particle size. Two soil gas samples were collected from the monitoring point and were labeled J-BKG-4.5′ and J-BKG. These samples were sent under chain of custody to Air Toxics, Ltd., in Rancho Cordova, California, for analyses of BTEX and TPH.

Results of the soil analyses for BTEX and TPH are presented in Table 14. The analytical report for this site is presented in Appendix B. Most of the BTEX compounds were at concentrations below the detection limit in soil samples, except for trace levels of toluene and total xylenes, whereas TPH concentrations were 16 to 70 mg/kg. The soil gas analyses also showed relatively low BTEX and TPH concentrations with concentrations ranging from below the detection limit for toluene, ethylbenzene, and total xylenes up to 0.017 ppmv of benzene. TPH concentrations were 2.6 to 6.5 ppmv (Table 14). The results of the soil chemistry analyses are summarized in Table 15.

An in situ respiration test was conducted at the background area beginning on February 23, 1993, after 24 hours of air injection. The test was concluded on February 25. No significant change in oxygen concentration was observed at this area (Figure 15).

Table 14. Results From Soil and Soil Gas Analyses for BTEX and TPH at the Background Area

Matrix	Sample Name	Benzene (mg/kg)	Toluene (mg/kg)	Ethylbenzene (mg/kg)	Total Xylenes (mg/kg)	TPH[1] (mg/kg)
Soil	J-BG-4.5′-5.0′	<0.0006	0.0009	<0.0005	0.0009	70
	J-BG-5.0′-5.5′	<0.0006	0.0005	<0.0005	0.0009	16
Matrix	**Sample Name**	**Benzene (ppmv)**	**Toluene (ppmv)**	**Ethylbenzene (ppmv)**	**Total Xylenes (ppmv)**	**TPH[2] (ppmv)**
Soil Gas	J-BKG-4.5′	0.003	<0.002	<0.002	0.003	6.5
	J-BKG	0.017	0.004	<0.002	<0.002	2.6

[1] Referenced to a reference oil composed of a mixture of 2,2,4-trimethylpentane, *n*-hexadecane, and chlorobenzene.

[2] TPH referenced to gasoline (molecular weight = 100).

Table 15. Results From Soil Chemistry Analyses at the Background Area

Parameter	Sample Name	
	J-BG-5.5'-6.0'	J-BG-6.0'-6.5'
Alkalinity (mg/kg $CaCO_3$)	360	370
Moisture (% by weight)	17.5	13.9
pH	8.9	9.0
Iron (mg/kg)	351	414
Total Phosphorous (mg/kg)	270	310
Total Kjeldahl Nitrogen (mg/kg)	140	260
Particle Size Analysis (%)	Gravel: 30	NA
	Sand: 54	NA
	Silt: 11	NA
	Clay: 5	NA

NA No analysis for this parameter.

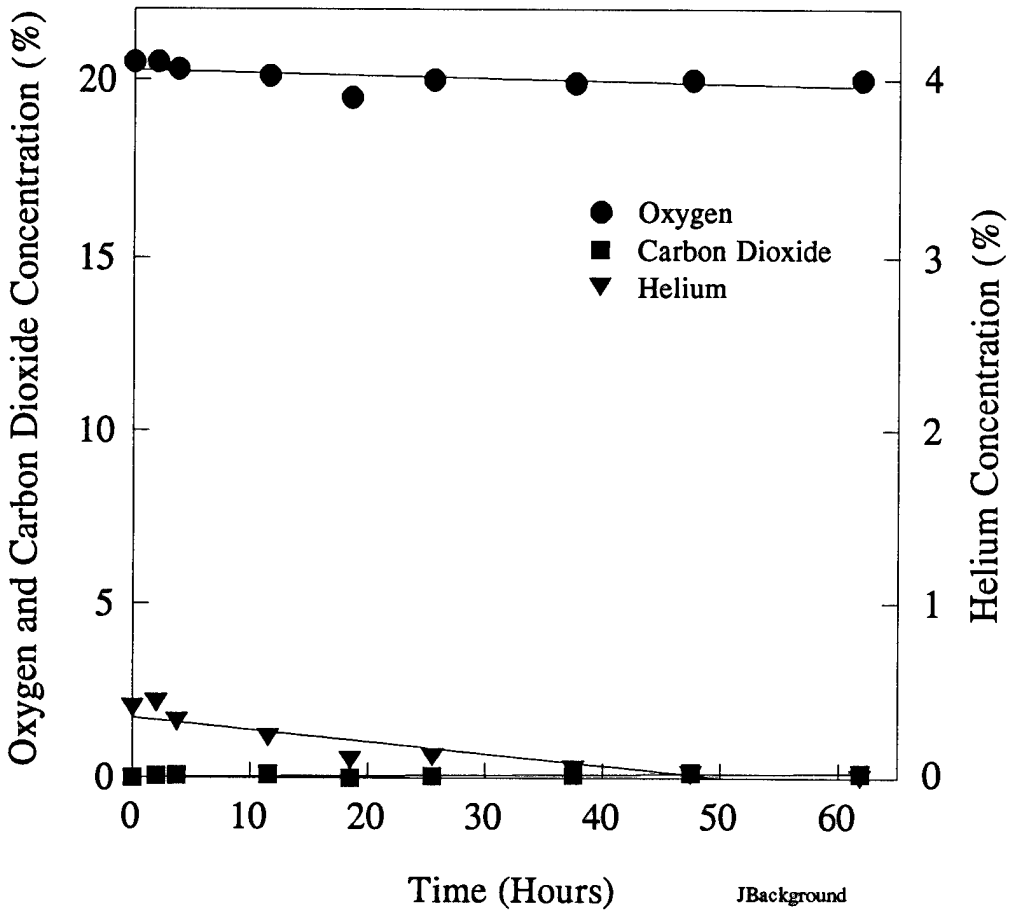


Figure 15. Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at the Background Area

7.0 FUTURE WORK

Base personnel will be required to perform a simple weekly system check to ensure that the blower is operating within its intended flowrate, pressure, and temperature range. An on-site briefing for base personnel who will be responsible for blower system checks was conducted when the blowers were installed. The principle of operation was explained, and a simple checklist and logbook were provided for blower data. Base personnel will be asked to perform minor maintenance activities, such as replacing filters or gauges, or draining condensate from knockout chambers, but they will not be expected to perform complicated repairs or analyze gas samples. Replacement filters and gauges will be provided and shipped to the base, and serious problems, such as motor or blower failures, will be corrected by Battelle.

The progress of this system will be monitored by conducting semiannual respiration tests in the vent well and in each monitoring point and by regularly measuring the oxygen, carbon dioxide, and hydrocarbon concentrations in the extracted soil gas and comparing them to background levels. At least twice each year, the progress of the bioventing test will be reported to the base point-of-contact.

8.0 REFERENCE

Hinchee, R.E., S.K. Ong, R.N. Miller, D.C. Downey, and R. Frandt. 1992. *Test Plan and Technical Protocol for a Field Treatability Test for Bioventing* (Rev. 2), Report prepared by Battelle Columbus Operations, U.S. Air Force Center for Environmental Excellence, and Engineering Sciences, Inc. for the U.S. Air Force Center for Environmental Excellence, Brooks Air Force Base, Texas.

APPENDIX A

TEST PLAN FOR JOHNSTON ISLAND FIELD COMMAND DEFENSE NUCLEAR AGENCY, JOHNSTON ATOLL

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January 18, 1993

Captain Catherine Vogel
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Dear Cathy:

SUBJECT: TEST PLAN FOR BIOVENTING INITIATIVE FIELD TEST AT STORAGE TANK 49, STORAGE TANKS 260 AND 261, AND THE FORMER POL AREA AT JOHNSTON ATOLL AFB, JOHNSTON ISLAND

This letter was prepared to accompany the report "Test Plan and Technical Protocol for a Field Treatability Test for Bioventing." The protocol document was developed as a generic test plan for the Air Force Bioventing Initiative Project in which Johnston Atoll AFS is participating. This letter outlines site specific information to support the generic test plan.

The sites chosen for the bioventing test initiative are Storage Tank 49, Storage Tanks 260 and 261, and the former POL Tank Farm Area adjacent to the base swimming pool.

The purpose of this project is to investigate the feasibility of using the bioventing technology to remediate petroleum contaminated soils at the above mentioned sites.

Site descriptions-

Johnston Atoll is an unincorporated territory of the United States located approximately 717 nautical miles west-southwest of Honolulu, Hawaii. Johnston Island (JI) is the largest of the four islands that make up the atoll with an area of approximately 625 acres (see Figure 1). The island soils are comprised mostly of dredged and filled coral from the lagoon. Soil gas surveys were performed at all three sites by the Air Force environmental contractor, Raytheon Services Nevada (RSN), in June of 1992. Summaries of the available data for each JI site proposed for the Bioventing Initiative are presented below.

Storage Tank #49-

Storage Tank #49 is a 557,000 gallon above ground diesel fuel tank located just west of the island power plant. Figure 2 shows soil gas hydrocarbon vapor contours in the vicinity of Tank #49. Soil gas analytical data for the Tank #49 area indicated petroleum hydrocarbon concentrations as high as 340 ppm, oxygen concentrations as low as 2%, and carbon dioxide concentrations as high as 12%.

340 ppm, oxygen concentrations as low as 2%, and carbon dioxide concentrations as high as 12%. This data would indicate that the Tank #49 site is a good candidate for bioventing.

Storage Tanks #260 and #261-

Storage Tanks #260 and #261 are located in the base POL tank farm. Each tank has an approximate capacity of 557,000 gallons of JP-5 fuel. Past spills of JP-5 jet fuel are known to have occurred here. Soil gas hydrocarbon concentrations in excess of 5000 ppm have been detected in the vicinity of tank #261. Figure 3 shows hydrocarbon vapor contours in the POL tank farm. Soil gas oxygen concentrations as low as 5% have been detected in the fuel farm area (see Figure 4). This data would indicate that the POL Tank farm site is a good candidate for bioventing.

Former POL Area-

In the 1940s and 1950s a POL tank farm was located in the area west of the site of the base swimming pool. Past spills and leaks in this area have resulted in petroleum hydrocarbon contamination in the area. The soil gas survey performed in this area in June of 1992 indicated soil gas hydrocarbon concentrations as high as 30,000 ppm (Figure 5) and oxygen concentrations as low as 1% (Figure 6). As for the other Johnston Island sites, this data would indicate that the former POL area site is a good candidate for bioventing.

Project activities-

The following field activities are planned for each site participating in bioventing project at JI. Additional detail can be found in Section 5.0 of the generic test plan and technical protocol.

1- A small scale soil gas survey will be conducted to identify an appropriate location for installation of the bioventing system. Soil vapor from the candidate site must exhibit high petroleum hydrocarbon concentrations (10,000 ppm or greater depending on contamination source), relatively low O_2 concentrations (0% to 2.0%), and relatively high CO_2 concentrations (depending on soil type, 2.0% to 10.0%). There are monitoring wells in the area of each site which may be good candidates for use as bioventing wells. The soil gas survey will be concentrated around these wells.

   An uncontaminated background location will also be identified using soil gas survey techniques.

2- Once the installation site is located, one vent well and three 3-level soil gas monitoring points will be installed in the contaminated location and one vent well will be installed in the background area. The existing monitoring wells will be evaluated for use as the bioventing air injection well. If none of the existing wells are suitable for use as the bioventing well, a trailer mounted drill rig (if available) with solid or hollow stem auger will be used to bore down to the water table and install a 2-inch vent well. A hand auger will be used to install the vent wells if the drill rig is not available. Three to four soil samples will be collected for chemical/physical analysis.

Sacrificial drive points will be used for the permanent (three-level) soil gas monitoring points, if possible. Otherwise, the three-level points will be installed using the portable drill rig.

3- The air permeability test will be conducted in the contaminated test location.

4- Following the air permeability test, in situ respiration tests will be conducted in both the contaminated and the background test locations.

5- Depending on the results of the air permeability test and the in situ respiration test, a decision will be made whether or not to install a blower system in the contaminated area for the long term bioventing test. If the decision is made to install, the blower will be plumbed to the vent well and bioventing will be started (assuming power is available). Site personnel will be trained for blower operation prior to Battelle leaving the site.

Schedule-

Field activities at Johnston Atoll are planned to begin on February 8, 1993. Battelle will have 3 people on site for 2 to 3 weeks.

Base Support-

Johnston Atoll needs to be able to provide the following:

- Digging permits and utility clearance for all sites need to be obtained prior to the initiation of the field work. Underground utilities should be clearly marked to reduce the chance of utility damage or personal injury during soil gas probe and well installation. Battelle will not be able to begin field operations without these clearances.

- Electrical power will need to be easily accessible from the project site. The air permeability test and in situ respiration test can be performed using a gasoline powered electric generator. The operation of the bioventing system will require a permanent 120 V, 20 amp, power source. If power will not be available immediately after the test is completed, the bioventing system will be installed for start-up at a later date. It would be best if power hook ups can be made before Battelle's field team leaves Johnston Island.

- The use of the drilling rig currently on JI would be very helpful in performing well installation and soil sampling. RSN has indicated that the rig may be available for our use. Please let us know if use of the drill rig will not be possible.

- Regulatory approval, if any is required, will need to be obtained by the base prior to start-up of the bioventing system. The system will likely be configured for air

injection so there will be no point source vapor emission from the system. No groundwater will be extracted from the sites.

- Drums for containment of contaminated soil cuttings (if required). The base will be responsible for disposition of any contaminated soils.

- We will need land transportation to transport personnel and equipment between the bioventing sites. A pick-up truck would be preferable.

- Site specific safety information will be needed for incorporation into Battelle's Health and Safety Plan. This information includes: emergency phone numbers for ambulance, fire department, security, etc... .

- Base and site clearance will be required for Battelle's site employees. We have furnished the base POC with personal information for each person in Battelle's field team (refer to our letter dated December 16, 1992).

Thank you for your support for this bioremediation research project. If you have any questions please feel free to call me at (614) 424-6122.

Sincerely,

Jeffrey A. Kittel
Researcher
Environmental Technology Department

JAK:sh

cc: Major Ross Miller (AFCEE)
Major Hermanski Patterson
FCDNA/FCJE
APO AP 96558

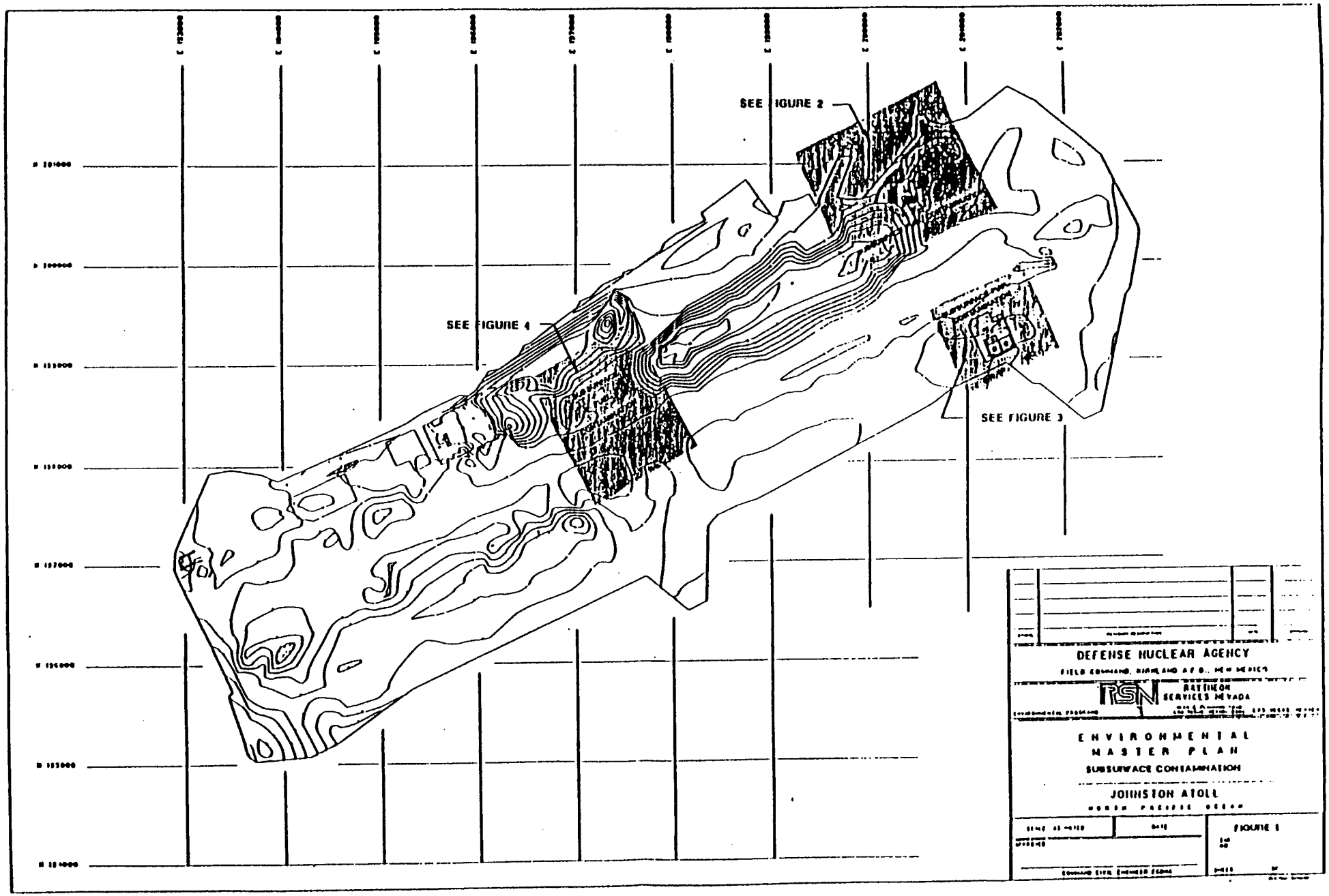


FIGURE 1. JOHNSTON ISLAND BASE MAP.

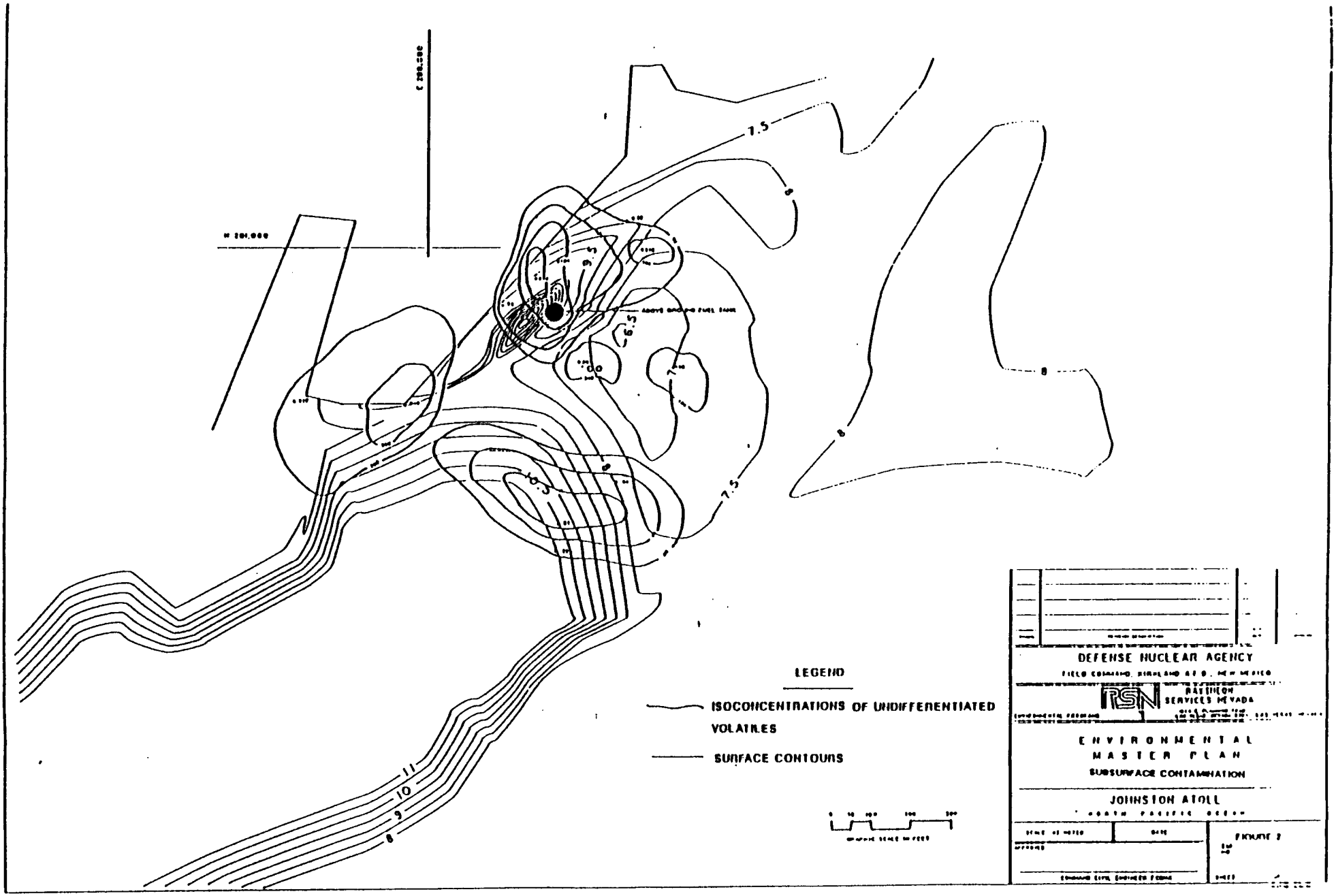


FIGURE 2. SITE MAP FOR TANK #49 BIOVENTING PROJECT.

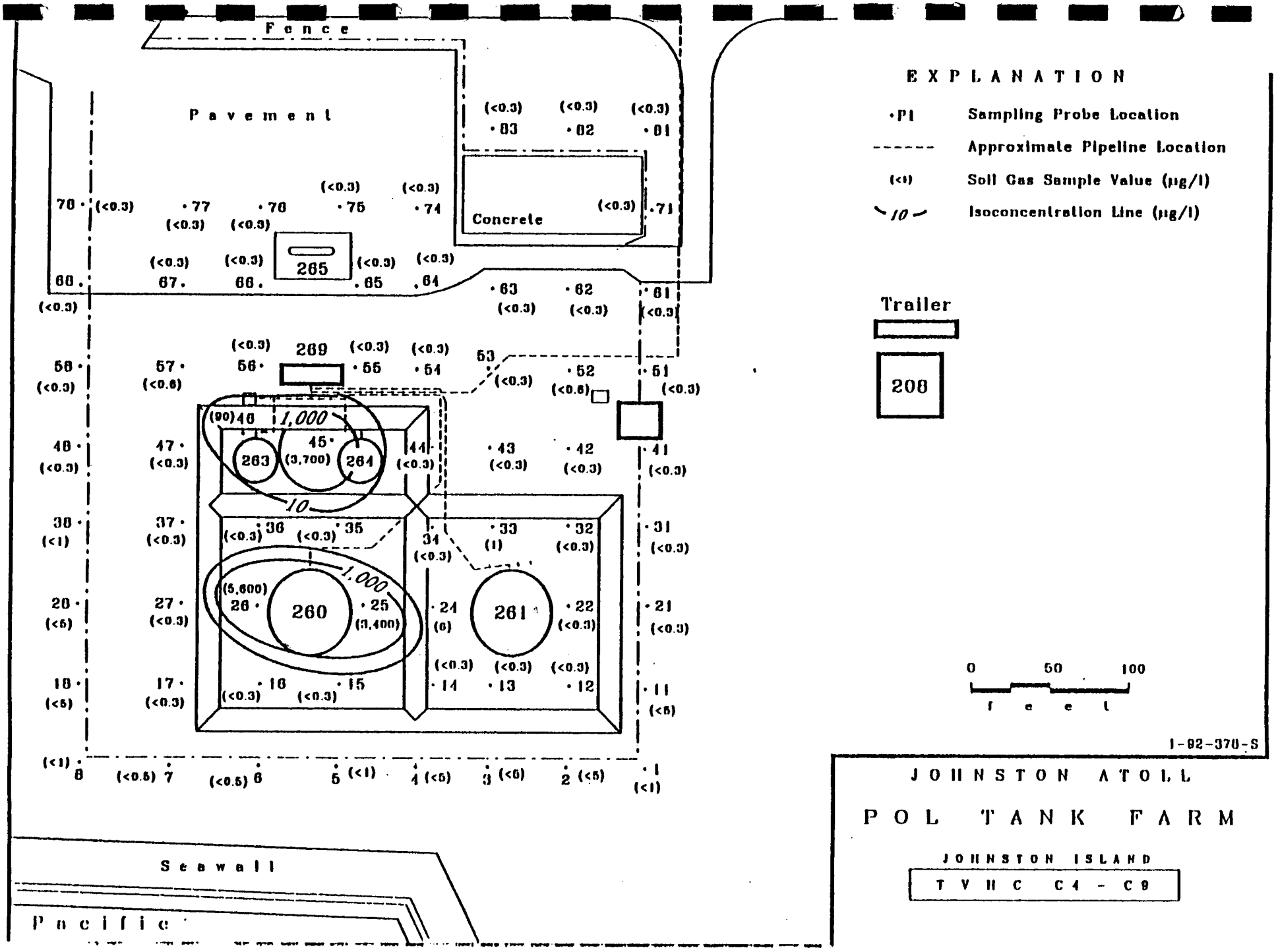


FIGURE 3. SOIL GAS HYDROCARBON CONCENTRATIONS AT THE TANK 260 AND TANK 261 BIOVENTING SITE.

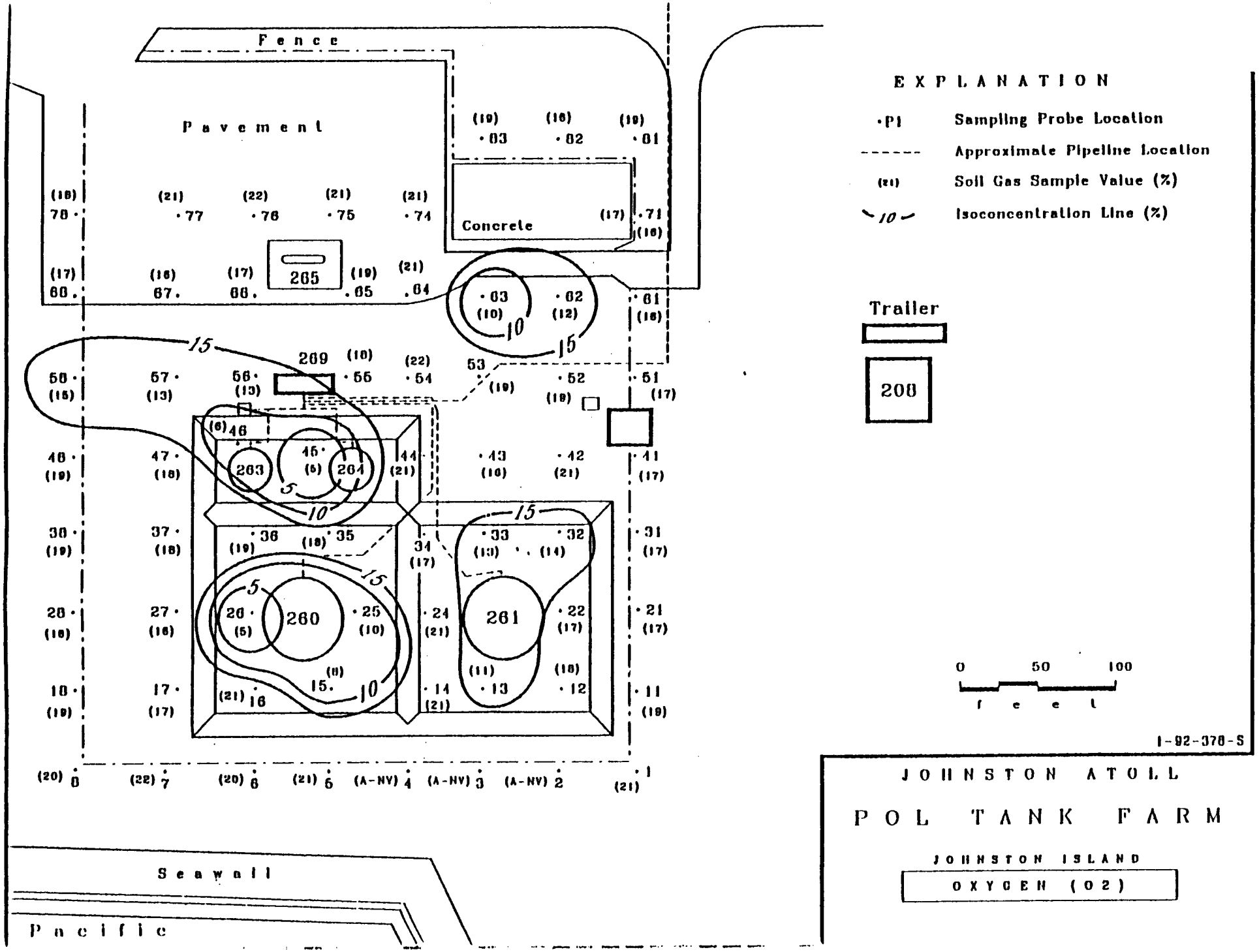


FIGURE 4. SOIL GAS OXYGEN CONCENTRATIONS AT THE TANK 260 AND TANK BIOVENTING

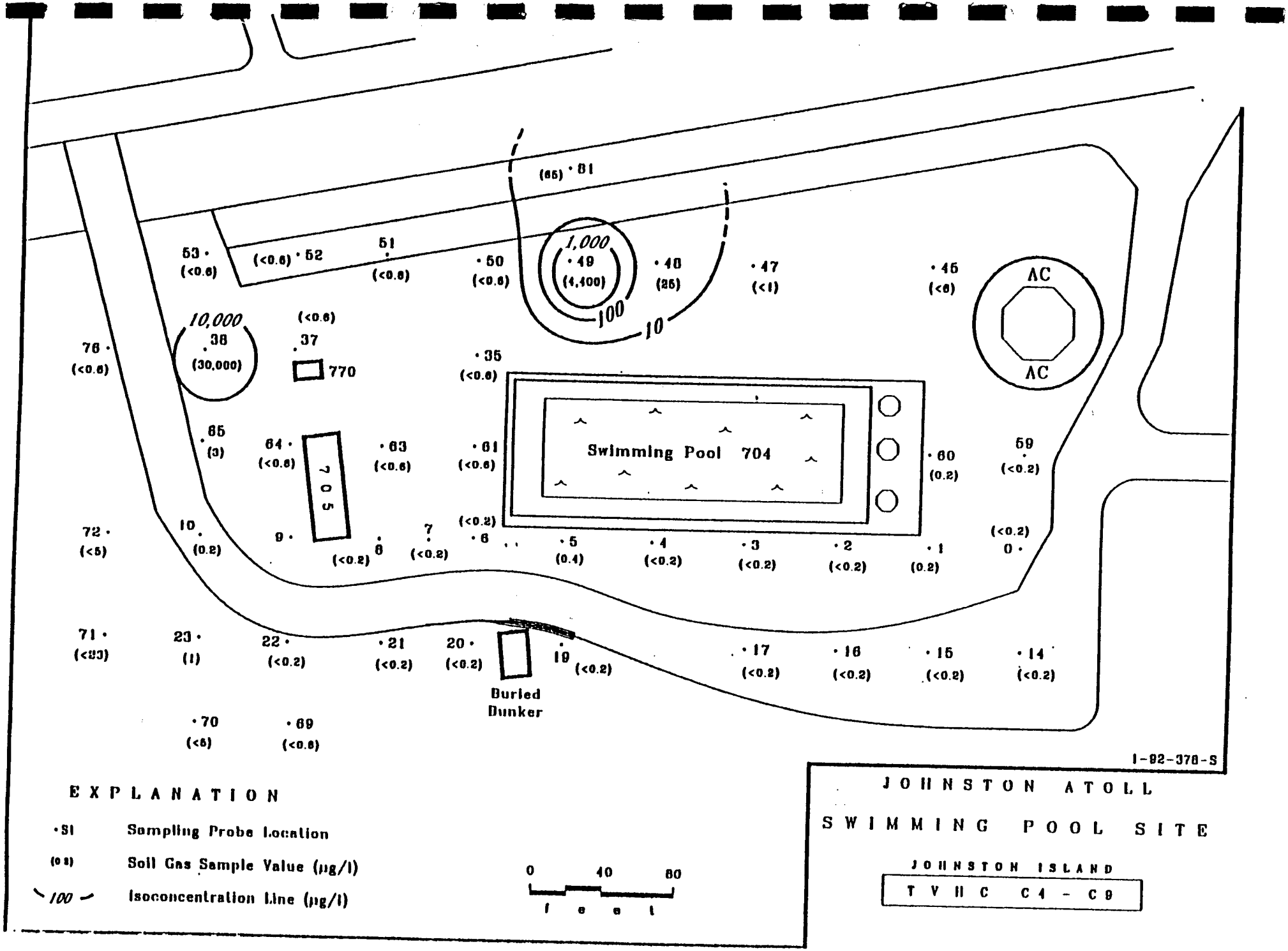
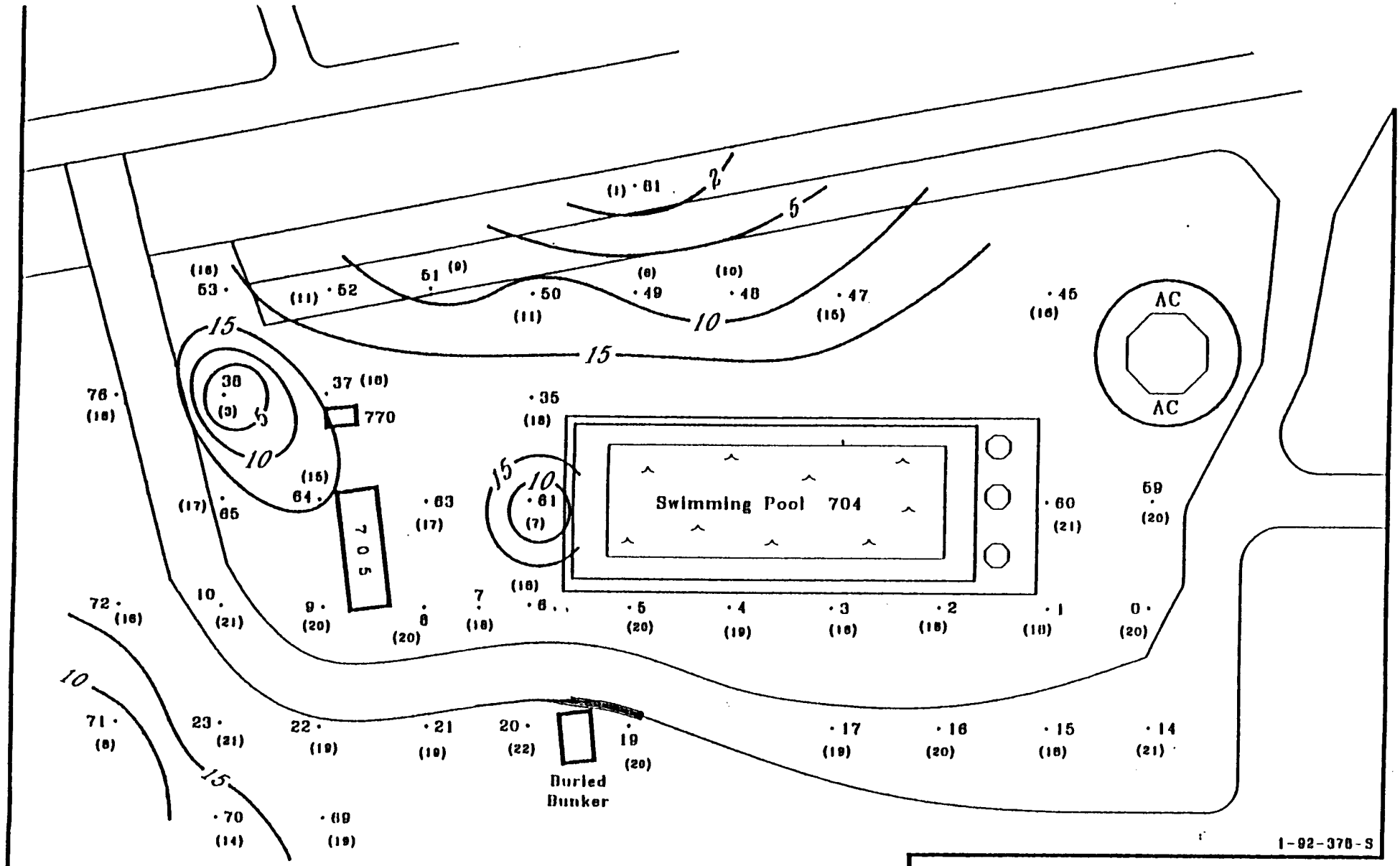


FIGURE 5. SOIL GAS HYDROCARBON CONCENTRATIONS AT THE OLD POL TANK FARM BIOVENTING SITE.



EXPLANATION

·51 Sampling Probe Location

(16) Soil Gas Sample Value (%)

~100~ Isoconcentration Line (%)

0 40 80

f e e t

JOHNSTON ATOLL

SWIMMING POOL SITE

JOHNSTON ISLAND

OXYGEN (O2)

FIGURE 6. GAS GEN CEN ION THE POL FAR
BIOVENTING SITE.

APPENDIX B

ANALYTICAL REPORT FOR THE OLD FIRE TRAINING AREA, THE FORMER POL TANK FARM, THE STORAGE TANKS 260 AND 261 SITE, THE STORAGE TANK 49 SITE, AND THE BACKGROUND AREA

@ AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

WORK ORDER #: 9303007

Work Order Summary

CLIENT: Mr. Jeff Kittel
Battelle
505 King Ave.
Columbus, OH 43201

BILL TO: Accounts Payable
Engineering Science
1700 Broadway , Ste. 900
Denver, CO 80290

PHONE: 614-424-6122
FAX: 614-424-3667
DATE RECEIVED: 3/2/93
DATE COMPLETED: 3/11/93

INVOICE # 0415
P.O. # 268.01
PROJECT # G4468-0615
AMOUNT$: $1,619.67

FRACTION #	NAME	TEST	RECEIPT VAC./PRES.	PRICE
01A	J2-MPA-4.5'	TO-3	0"Hg	$120.00
02A	J2-MPA-2.5'	TO-3	0"Hg	$120.00
03A	J2-MPB-4.5'	TO-3	1.0 "Hg	$120.00
04A	J1-MPA-2.5'	TO-3	1.5 "Hg	$120.00
05A	J1-MPB-4.5'	TO-3	1.5 "Hg	$120.00
06A	J1-MPA-4.5'	TO-3	2.0 "Hg	$120.00
07A	J3-MPB-4.5'	TO-3	1.5 "Hg	$120.00
08A	J3-MPC-2.5'	TO-3	1.0 "Hg	$120.00
09A	J3-MPA-2.5'	TO-3	1.0 "Hg	$120.00
10A	J3-MPC-4.5'	TO-3	1.0 "Hg	$120.00
10B	J3-MPC-4.5' Duplicate	TO-3	1.0 "Hg	NC
11A	J-BKG-4.5'	TO-3	1.0 "Hg	$120.00
12A	J-BKG	TO-3	1.5 "Hg	$120.00
13A	Method Spike	TO-3	NA	NC
14A	Lab Blank	TO-3	NA	NC
14B	Lab Blank	TO-3	NA	NC

Mics Charges	1 Liter SUMMA Canister (12) @ $ 10.00 each.	$120.00
	Shipping (1/29/93)	$59.67

CERTIFIED BY: Linda L. Freeman
Laboratory Director

DATE: 3/11/93

11325 SUNRISE GOLD CIRCLE, SUITE E • RANCHO CORDOVA, CA 95742
(916) 638-9892 • FAX (916) 638-9917

AIR TOXICS LTD.

SAMPLE NAME: J2-MPA-4.5'
ID#: 9303007-01A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name:	**6030320**	**Date of Collection:**	**2/22/93**
Dil. Factor:	**200**	**Date of Analysis:**	**3/3/93**

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.20	0.62	Not Detected	Not Detected
Toluene	0.20	0.74	Not Detected	Not Detected
Ethyl Benzene	0.20	0.85	3.2	14
Total Xylenes	0.20	0.85	2.4	10

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	**6030320**	**Date of Collection:**	**2/22/93**
Dil. Factor:	**200**	**Date of Analysis:**	**3/3/93**

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	2.0	12	3700	23000

*TPH referenced to Jet Fuel (MW=156)

Container Type: 1 Liter SUMMA Canister

AIR TOXICS LTD.

SAMPLE NAME: J2-MPA-2.5'
ID#: 9303007-02A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name: 6030319 **Date of Collection: 2/22/93**
Dil. Factor: 200 **Date of Analysis: 3/3/93**

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.20	0.62	Not Detected	Not Detected
Toluene	0.20	0.74	Not Detected	Not Detected
Ethyl Benzene	0.20	0.85	2.3	9.8
Total Xylenes	0.20	0.85	2.3	9.8

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name: 6030319 **Date of Collection: 2/22/93**
Dil. Factor: 200 **Date of Analysis: 3/3/93**

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	2.0	12	3400	21000

*TPH referenced to Jet Fuel (MW=156)

Container Type: 1 Liter SUMMA Canister

AIR TOXICS LTD.

SAMPLE NAME: J2-MPB-4.5'
ID#: 9303007-03A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name:	**6030321**	**Date of Collection:**	**2/22/93**
Dil. Factor:	**260**	**Date of Analysis:**	**3/3/93**

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.26	0.8	Not Detected	Not Detected
Toluene	0.26	1.0	Not Detected	Not Detected
Ethyl Benzene	0.26	1.1	3.6	15
Total Xylenes	0.26	1.1	2.1	8.9

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	**6030321**	**Date of Collection:**	**2/22/93**
Dil. Factor:	**260**	**Date of Analysis:**	**3/3/93**

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	2.6	16	4400	27000

*TPH referenced to Jet Fuel (MW=156)

Container Type: 1 Liter SUMMA Canister

AIR TOXICS LTD.

SAMPLE NAME: J1-MPA-2.5'
ID#: 9303007-04A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name:	**6030323**	**Date of Collection:**	**2/22/93**
Dil. Factor:	**21**	**Date of Analysis:**	**3/3/93**

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.021	0.066	Not Detected	Not Detected
Toluene	0.021	0.077	0.20	0.74
Ethyl Benzene	0.021	0.089	0.90	3.8
Total Xylenes	0.021	0.089	2.0	8.5

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	**6030323**	**Date of Collection:**	**2/22/93**
Dil. Factor:	**21**	**Date of Analysis:**	**3/3/93**

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	0.21	1.3	510	3100

*TPH referenced to Jet Fuel (MW=156)

Container Type: 1 Liter SUMMA Canister

AIR TOXICS LTD.

SAMPLE NAME: J1-MPB-4.5'
ID#: 9303007-05A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name:	**6030324**	**Date of Collection:**	**2/22/93**
Dil. Factor:	**53**	**Date of Analysis:**	**3/3/93**

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.053	0.17	Not Detected	Not Detected
Toluene	0.053	0.20	1.2	4.4
Ethyl Benzene	0.053	0.22	1.5	6.4
Total Xylenes	0.053	0.22	5.2	22

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	**6030324**	**Date of Collection:**	**2/22/93**
Dil. Factor:	**53**	**Date of Analysis:**	**3/3/93**

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	0.53	3.3	510	3100

*TPH referenced to Jet Fuel (MW=156)

Container Type: 1 Liter SUMMA Canister

AIR TOXICS LTD.

SAMPLE NAME: J1-MPA-4.5'
ID#: 9303007-06A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name:	**6030325**	**Date of Collection:**	**2/22/93**
Dil. Factor:	**22**	**Date of Analysis:**	**3/3/93**

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.022	0.069	Not Detected	Not Detected
Toluene	0.022	0.081	Not Detected	Not Detected
Ethyl Benzene	0.022	0.093	0.46	2.0
Total Xylenes	0.022	0.093	1.2	5.1

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	**6030325**	**Date of Collection:**	**2/22/93**
Dil. Factor:	**22**	**Date of Analysis:**	**3/3/93**

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	0.22	1.4	330	2000

*TPH referenced to Jet Fuel (MW=156)

Container Type: 1 Liter SUMMA Canister

AIR TOXICS LTD.

SAMPLE NAME: J3-MPB-4.5'
ID#: 9303007-07A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name:	**6030326**	**Date of Collection: 2/27/93**	
Dil. Factor:	**110**	**Date of Analysis: 3/3/93**	

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.11	0.34	Not Detected	Not Detected
Toluene	0.11	0.40	Not Detected	Not Detected
Ethyl Benzene	0.11	0.47	2.4	10
Total Xylenes	0.11	0.47	2.5	11

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	**6030326**	**Date of Collection: 2/27/93**	
Dil. Factor:	**110**	**Date of Analysis: 3/3/93**	

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	1.1	6.9	1900	12000

*TPH referenced to Jet Fuel (MW=156)

Container Type: 1 Liter SUMMA Canister

AIR TOXICS LTD.

SAMPLE NAME: J3-MPC-2.5'
ID#: 9303007-08A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name:	**6030407**	**Date of Collection:**	**2/27/93**
Dil. Factor:	**210**	**Date of Analysis:**	**3/4/93**

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.21	0.66	Not Detected	Not Detected
Toluene	0.21	0.77	Not Detected	Not Detected
Ethyl Benzene	0.21	0.89	1.9	8.1
Total Xylenes	0.21	0.89	2.2	9.3

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	**6030407**	**Date of Collection:**	**2/27/93**
Dil. Factor:	**210**	**Date of Analysis:**	**3/4/93**

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	2.1	13	1700	10000

*TPH referenced to Jet Fuel (MW=156)

Container Type: 1 Liter SUMMA Canister

AIR TOXICS LTD.

SAMPLE NAME: J3-MPA-2.5'
ID#: 9303007-09A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name:	**6030408**	**Date of Collection:**	**2/27/93**
Dil. Factor:	**100**	**Date of Analysis:**	**3/4/93**

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.10	0.31	Not Detected	Not Detected
Toluene	0.10	0.37	Not Detected	Not Detected
Ethyl Benzene	0.10	0.42	1.2	5.1
Total Xylenes	0.10	0.42	2.4	10

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	**6030408**	**Date of Collection:**	**2/27/93**
Dil. Factor:	**100**	**Date of Analysis:**	**3/4/93**

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	1.0	6.2	2100	13000

*TPH referenced to Jet Fuel (MW=156)

Container Type: 1 Liter SUMMA Canister

AIR TOXICS LTD.

SAMPLE NAME: J3-MPC-4.5'
ID#: 9303007-10A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name:	**6030409**	**Date of Collection:**	**2/27/93**
Dil. Factor:	**52**	**Date of Analysis:**	**3/4/93**

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.052	0.16	Not Detected	Not Detected
Toluene	0.052	0.19	Not Detected	Not Detected
Ethyl Benzene	0.052	0.22	0.48	2.0
Total Xylenes	0.052	0.22	0.80	3.4

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	**6030409**	**Date of Collection:**	**2/27/93**
Dil. Factor:	**52**	**Date of Analysis:**	**3/4/93**

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	0.52	3.2	650	4000

*TPH referenced to Jet Fuel (MW=156)

Container Type: 1 Liter SUMMA Canister

AIR TOXICS LTD.

SAMPLE NAME: J3-MPC-4.5' Duplicate
ID#: 9303007-10B

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name: 6030410 **Date of Collection: 2/27/93**
Dil. Factor: 52 **Date of Analysis: 3/4/93**

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.052	0.16	Not Detected	Not Detected
Toluene	0.052	0.19	Not Detected	Not Detected
Ethyl Benzene	0.052	0.22	0.52	2.2
Total Xylenes	0.052	0.22	0.86	3.6

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name: 6030410 **Date of Collection: 2/27/93**
Dil. Factor: 52 **Date of Analysis: 3/4/93**

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	0.52	3.2	680	4200

*TPH referenced to Jet Fuel (MW=156)

Container Type: 1 Liter SUMMA Canister

AIR TOXICS LTD.

SAMPLE NAME: J-BKG-4.5'
ID#: 9303007-11A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name:	**6030411**	**Date of Collection:**	**2/22/93**
Dil. Factor:	**2.1**	**Date of Analysis:**	**3/4/93**

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.002	0.007	0.003	0.009
Toluene	0.002	0.008	Not Detected	Not Detected
Ethyl Benzene	0.002	0.009	Not Detected	Not Detected
Total Xylenes	0.002	0.009	0.003	0.013

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	**6030411**	**Date of Collection:**	**2/22/93**
Dil. Factor:	**2.1**	**Date of Analysis:**	**3/4/93**

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	0.021	0.13	6.5	40

*TPH referenced to Jet Fuel (MW=156)

Container Type: 1 Liter SUMMA Canister

AIR TOXICS LTD.

SAMPLE NAME: J-BKG
ID#: 9303007-12A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name:	**6030412**	**Date of Collection:**	**2/27/93**
Dil. Factor:	**2.1**	**Date of Analysis:**	**3/4/93**

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.002	0.007	0.017	0.053
Toluene	0.002	0.008	0.004	0.015
Ethyl Benzene	0.002	0.009	Not Detected	Not Detected
Total Xylenes	0.002	0.009	Not Detected	Not Detected

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	**6030412**	**Date of Collection:**	**2/27/93**
Dil. Factor:	**2.1**	**Date of Analysis:**	**3/4/93**

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	0.021	0.13	2.6	16

*TPH referenced to Jet Fuel (MW=156)

Container Type: 1 Liter SUMMA Canister

AIR TOXICS LTD.

SAMPLE NAME: Method Spike
ID#: 9303007-13A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name: 6030401 **Date of Collection: NA**
Dil. Factor: 1.0 **Date of Analysis: 3/4/93**

Compound	MDL (ppmv)	MDL (uG/L)	% Recovery
Benzene	0.001	0.003	101
Toluene	0.001	0.004	101
Ethyl Benzene	0.001	0.004	101
Total Xylenes	0.001	0.004	99

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name: 6030401 **Date of Collection: NA**
Dil. Factor: 1.0 **Date of Analysis: 3/4/93**

Compound	MDL (ppmv)	MDL (uG/L)	% Recovery
TPH*	0.010	0.062	100

*TPH referenced to Jet Fuel (MW=156)

Container Type: NA

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank
ID#: 9303007-14A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name:	**6030315**	**Date of Collection: NA**	
Dil. Factor:	**1.0**	**Date of Analysis: 3/3/93**	

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.001	0.003	Not Detected	Not Detected
Toluene	0.001	0.004	Not Detected	Not Detected
Ethyl Benzene	0.001	0.004	Not Detected	Not Detected
Total Xylenes	0.001	0.004	Not Detected	Not Detected

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	**6030315**	**Date of Collection: NA**	
Dil. Factor:	**1.0**	**Date of Analysis: 3/3/93**	

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	0.010	0.062	Not Detected	Not Detected

*TPH referenced to Jet Fuel (MW=156)

Container Type: NA

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank
ID#: 9303007-14B

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name:	**6030405**	**Date of Collection:**	**NA**
Dil. Factor:	**1.0**	**Date of Analysis:**	**3/4/93**

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.001	0.003	Not Detected	Not Detected
Toluene	0.001	0.004	Not Detected	Not Detected
Ethyl Benzene	0.001	0.004	Not Detected	Not Detected
Total Xylenes	0.001	0.004	Not Detected	Not Detected

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:	**6030405**	**Date of Collection:**	**NA**
Dil. Factor:	**1.0**	**Date of Analysis:**	**3/4/93**

Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	0.010	0.062	Not Detected	Not Detected

*TPH referenced to Jet Fuel (MW=156)

Container Type: NA

AIR TOXICS LTD.
AN ENVIRONMENTAL ANALYTICAL LABORATORY

11325 SUNRISE GOLD CIRCLE, SUITE 'E'
RANCHO CORDOVA, CA 95742
(916) 638-9892 • FAX (916) 638-9917

CHAIN OF CUSTODY RECORD

Page 1 of 1

PROJECT # G4468-0615 JOB # Engineering Science 268.01 PO # _____ COLLECTED BY (Signature) D. Kittel / G. Healy for W

REMARKS JOHNSTON ATOLL / SEND RESULT TO: JEFF KITTEL / BATTELLE, 505 KING AVE, Columbus, OH 43201 (614) 424-6122

	FIELD SAMPLE I.D.#	SAMPLING MEDIA (Tenax, Canister etc.)	DATE/TIME	ANALYSIS	VAC./PRESSURE	CAN # LAB I.D. #
01A	J2-MPA-4.5'	CANISTER	22 FEB 93 / 2020	BTEX / TPH	0	11444
02A	J2-MPA-2.5'	"	22 FEB 93 / 2000	"	0	12804
03A	J2-MPB-4.5'	"	22 FEB 93 / 2000	"	1.0"	12367
04A	J1-MPA-2.5'	"	22 FEB 93 / 1430	"	1.5"	12807
05A	J1-MPB-4.5'	"	22 FEB 93 / 1435	"	1.5"	12357
06A	J1-MPA-4.5'	"	22 FEB 93 / 1440	"	2.0"	11835
07A	J3-MPB-4.5'	"	27 FEB 93 / 1120	"	1.5"	12360
08A	J3-MPC-2.5'	"	27 FEB 93 / 1120	"	1.0"	12370
09A	J3-MPA-2.5'	"	27 FEB 93 / 1120	"	1.0" Hg	11439
10A/B	J3-MPC-4.5'	"	27 FEB 93 / 1120	"	1.0" Hg	11823
11A	J-BKG-4.5'	"	22 FEB 93 / 1440		1.0" Hg	11894
12A	J-BKG	"	27 FEB 93 / 1600		1.5" Hg	12390

RELINQUISHED BY: DATE/TIME	RECEIVED BY: DATE/TIME	RELINQUISHED BY: DATE/TIME	RECEIVED BY: DATE/TIME
Jeff Healy 28 FEB 93			

LAB USE ONLY

SHIPPER NAME	AIR BILL #	OPENED BY: DATE/TIME	TEMP(°C)	CONDITION
FED-X	5191923804	Lynn A Freeman ATL 3/2/93 10:00		

REMARKS _____

ENGINEERING-SCIENCE, INC.

600 BANCROFT WAY
BERKELEY, CA 94710
Tel: (415) 548-7970 Fax: (415) 548-7635

Report Date: March 22, 1993

Work Order No.: 4840

Client: Doug Downey
ES Denver/AFCEE (Battelle/Bioventing)
1700 Broadway
Denver, CO 80290

Date of Sample Receipt: 2/26/93

Your soil samples identified as:

J1VW1-4.5'-5.0'
J1VW1-5'-5.5'
J2VW4.5'-5.0'
J2VW5.0'-5.5'
J3VW4.0'-4.5'
J3VW4.5'-5.0'

were analyzed for BTEX by EPA Method 8020, TPH by EPA Method 418.1, alkalinity, iron, pH, moisture, total Kjeldahl nitrogen, total phosphorous and soil classification.

In addition, your soil samples identified as:

JBG4.5'-5.0'
JBG5.0'-5.5'

were analyzed for BTEX by EPA Method 8020 and TPH by EPA Method 418.1.

Finally, your soil samples identified as:

JBG5.5'-6.0'
JBG6'-6.5'

were analyzed for alkalinity, iron, pH, moisture, total kjeldahl nitrogen, total phosphourus and soil classification.

The analytical reports for the samples listed above are attached.

GC VOLATILES DATA PACKAGE

VOLATILE ORGANICS CASE NARRATIVE
WORK ORDER NO. 4840
MODIFIED EPA METHOD 8020

Samples J1VW1-4.5'-5.0' (4840-03), J1VW1-5'-5.5' (4840-04), J2VW4.5'-5.0' (4840-05), J2VW5.0'-5,5' (4840-06), JV3VW4.0'-4.5' (4840-07) and J3VW4.5'-5.0' (4840-08) were analyzed as medium level soils due to hydrocarbon interference which resulted in elevated detection limits for these samples.

ES-ENGINEERING SCIENCE, INC.

600 Bancroft Way
Berkeley,CA 94710

GC ANALYTICAL REPORT
Analytical Method
BTEX Aromatic Compounds

Work Order NO.:4840 % Moisture:NA

Client ID:JBG4.5'-5.0' Matrix:SOIL

Laboratory ID:4840-1 Level:LOW

Date Collected: 02/21/93 Unit:UG/KG

Dilution Factor: 1 Date Analyzed:03/04/93
Date Confirmed:NA

Compound	Result	Reporting Limit
Benzene	ND	0.6
Ethyl Benzene	ND	0.5
Toluene	0.9	0.7
Xylenes (total)	ND	0.9

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: AB

GROUP LEADER: 3/12/93

ES-ENGINEERING SCIENCE, INC.
600 Bancroft Way
Berkeley,CA 94710

GC ANALYTICAL REPORT
Analytical Method
BTEX Aromatic Compounds

Work Order NO.:4840 % Moisture:NA

Client ID:JBG5.0'-5.5' Matrix:SOIL

Laboratory ID:4840-2 Level:LOW

Date Collected: 02/21/93 Unit:UG/KG

Dilution Factor: 1 Date Analyzed:03/04/93
Date Confirmed:NA

Compound	Result	Reporting Limit
Benzene	ND	0.6
Ethyl Benzene	ND	0.5
Toluene	ND	0.7
Xylenes (total)	ND	0.9

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: NB

GROUP LEADER: 3/12/93

ES-ENGINEERING SCIENCE, INC.
600 Bancroft Way
Berkeley,CA 94710

GC ANALYTICAL REPORT
Analytical Method
BTEX Aromatic Compounds

Work Order NO.:4840 % Moisture: 10.74

Client ID:J1VW1-4.5'-5.0' Matrix:SOIL

Laboratory ID:4840-3 Level:MEDIUM

Date Collected: 02/21/93 Unit:UG/KG

Dilution Factor: 10 Date Analyzed:03/02/93
Date Confirmed:NA

Compound	Result	Reporting Limit
Benzene	ND	670.0
Ethyl Benzene	560.0	560.0
Toluene	ND	790.0
Xylenes (total)	ND	1000.0

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: AP

GROUP LEADER:

ES-ENGINEERING SCIENCE, INC.
600 Bancroft Way
Berkeley,CA 94710

GC ANALYTICAL REPORT
Analytical Method
BTEX Aromatic Compounds

Work Order NO.:4840 % Moisture: 11.3

Client ID:J1VW1-5'-5.5' Matrix:SOIL

Laboratory ID:4840-4 Level:MEDIUM

Date Collected: 02/21/93 Unit:UG/KG

Dilution Factor: 10 Date Analyzed:03/02/93
Date Confirmed:NA

Compound	Result	Reporting Limit
Benzene	ND	670.0
Ethyl Benzene	670.0	560.0
Toluene	900.0	790.0
Xylenes (total)	ND	1000.0

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: AB

GROUP LEADER: 3/12/93

ES-ENGINEERING SCIENCE, INC.

600 Bancroft Way
Berkeley,CA 94710

GC ANALYTICAL REPORT
Analytical Method
BTEX Aromatic Compounds

Work Order NO.:4840

% Moisture: 10.98

Client ID:J2VW4.5'-5.0'

Matrix:SOIL

Laboratory ID:4840-5

Level:MEDIUM

Date Collected: 02/21/93

Unit:UG/KG

Dilution Factor: 20

Date Analyzed:03/02/93
Date Confirmed:NA

Compound	Result	Reporting Limit
Benzene	ND	1300.0
Ethyl Benzene	3100.0	1100.0
Toluene	ND	1600.0
Xylenes (total)	2500.0	2000.0

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: AB

GROUP LEADER: 3/12/93

ES-ENGINEERING SCIENCE, INC.

600 Bancroft Way
Berkeley,CA 94710

GC ANALYTICAL REPORT
Analytical Method
BTEX Aromatic Compounds

Work Order NO.:4840 % Moisture: 10.31

Client ID:J2VW5.0'-5.5' Matrix:SOIL

Laboratory ID:4840-6 Level:MEDIUM

Date Collected: 02/21/93 Unit:UG/KG

Dilution Factor: 50 Date Analyzed:03/02/93
Date Confirmed:NA

Compound	Result	Reporting Limit
Benzene	ND	3300.0
Ethyl Benzene	3900.0	2800.0
Toluene	ND	3900.0
Xylenes (total)	ND	5000.0

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: AS

GROUP LEADER: 3/12/93

ES-ENGINEERING SCIENCE, INC.

600 Bancroft Way
Berkeley,CA 94710

GC ANALYTICAL REPORT
Analytical Method
BTEX Aromatic Compounds

Work Order NO.:4840 % Moisture: 12.42

Client ID:J3VW4.0'-4.5' Matrix:SOIL

Laboratory ID:4840-7 Level:MEDIUM

Date Collected: 02/23/93 Unit:UG/KG

Dilution Factor: 10 Date Analyzed:03/02/93
Date Confirmed:NA

Compound	Result	Reporting Limit
Benzene	ND	680.0
Ethyl Benzene	4400.0	570.0
Toluene	ND	800.0
Xylenes (total)	4100.0	1000.0

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: AB

GROUP LEADER: 3/12/93

ES-ENGINEERING SCIENCE, INC.
600 Bancroft Way
Berkeley,CA 94710

GC ANALYTICAL REPORT
Analytical Method
BTEX Aromatic Compounds

Work Order NO.:4840 % Moisture: 12.51

Client ID:J3VW4.5'-5.0' Matrix:SOIL

Laboratory ID:4840-8 Level:MEDIUM

Date Collected: 02/23/93 Unit:UG/KG

Dilution Factor: 50 Date Analyzed:03/02/93
Date Confirmed:NA

Compound	Result	Reporting Limit
Benzene	ND	3400.0
Ethyl Benzene	26000.0	2900.0
Toluene	ND	4000.0
Xylenes (total)	23000.0	5200.0

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: AB

GROUP LEADER:

ES-ENGINEERING SCIENCE, INC.

600 Bancroft Way
Berkeley,CA 94710

GC ANALYTICAL REPORT
Analytical Method
BTEX Aromatic Compounds

Work Order NO.:4840 % Moisture:NA

Client ID:METHOD BLANK Matrix:SOIL

Laboratory ID:MWVG3930302 Level:MEDIUM

Date Collected: NA Unit:UG/KG

Dilution Factor: 1 Date Analyzed:03/02/93
Date Confirmed:NA

Compound	Result	Reporting Limit
Benzene	ND	60.0
Ethyl Benzene	ND	50.0
Toluene	ND	70.0
Xylenes (total)	ND	90.0

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST:

GROUP LEADER:

ES-ENGINEERING SCIENCE, INC.
600 Bancroft Way
Berkeley,CA 94710

GC ANALYTICAL REPORT
Analytical Method
BTEX Aromatic Compounds

Work Order NO.:4840 % Moisture:NA

Client ID:METHOD BLANK Matrix:SOIL

Laboratory ID:MSVG3930304 Level:LOW

Date Collected: NA Unit:UG/KG

Dilution Factor: 1 Date Analyzed:03/04/93
Date Confirmed:NA

Compound	Result	Reporting Limit
Benzene	ND	0.6
Ethyl Benzene	ND	0.5
Toluene	ND	0.7
Xylenes (total)	ND	0.9

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: RB

GROUP LEADER: 3/12/93

ES-ENGINEERING SCIENCE,INC.
600 BANCROFT WAY
BERKELEY, CA 94710

GC ANALYTICAL REPORT
ANALYTICAL REPORT
BTEX AROMATIC COMPOUNDS

MATRIX: SOIL

DATE:03/02/93

LABORATORY NO.	CLIENT ID	a-a-a-TriFluoro Toluene
MWVG3930302	METHOD BLANK	103
4840-3	J1VW1-4.5'-5.0'	95
4840-4	J1VW1-5'-5.5'	102
4840-5	J2VW4.5'-5.0'	92
4840-6	J2VW5.0'-5.5'	92
4840-7	J3VW4.0'-4.5'	76
4840-8	J3VW4.5'-5.0'	74

ES-ENGINEERING SCIENCE,INC.

600 BANCROFT WAY
BERKELEY, CA 94710

GC ANALYTICAL REPORT
ANALYTICAL REPORT
BTEX AROMATIC COMPOUNDS

MATRIX: SOIL

DATE:03/04/93

LABORATORY NO.	CLIENT ID	a-a-a-TriFluoro Toluene
MSVG3930304	METHOD BLANK	108
SSVG3930304A	SPIKE	100
SSVG3930304B	SPIKE DUP	99
4840-1	JBG4.5'-5.0'	104
4840-2	JBG5.0'-5.5'	98

ES-ENGINEERING SCIENCE, INC.

600 Bancroft Way
Berkeley, CA 94710

QUALITY CONTROL RESULTS SUMMARY
ANALYTICAL REPORT
BTEX AROMATIC COMPOUNDS

Work Order No.: 4840

QC sample No.: SSVG3930304A&B Date analyzed: 03/04/93

Matrix: SOIL Dilution factor: 1

COMPOUND				MS		MSD			QC LIMITS	
8020 analysis	SA UG/L	SR UG/L	MS UG/L	PR	MSD UG/L	PR	RPD	RPD	PR
Benzene	20	ND	17.1	86	16.4	82	4	29	39-150
Toluene	20	ND	17.3	87	16.5	83	5	28	46-148

MS = Spike sample
MSD = Spike sample duplicate
SR = Sample result
SA = Spike added
ND = Not Found At or Above Detection Limits

NC = Not calculated
NA = Not Applicable
** = Out of limits

RPD = 100 x (MS-MSD)/((MS+MSD)/2)

PR = 100 x ((MS or MSD) - SR)/SA

ANALYST: [signature]

QC: [signature]

METHOD BLANK SUMMARY

WO # 4840

LAB NAME : ENGINEERING-SCIENCE, INC. DATE ANALYZED :03/02/93

LAB SAMPLE ID:MWVG3930302 DATE EXTRACTED : NA

MATRIX :SOIL INSTRUMENT ID:VGC-3

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE ANALYZED
MWVG3930302	METHOD BLANK	03/02/93
4840-3	J1VW1-4.5'-5.0'	03/02/93
4840-4	J1VW1-5'-5.5'	03/02/93
4840-5	J2VW4.5'-5.0'	03/02/93
4840-6	J2VW5.0'-5.5'	03/02/93
4840-7	J3VW4.0'-4.5'	03/02/93
4840-8	J3VW4.5'-5.0'	03/02/93

METHOD BLANK SUMMARY

WO # 4840

LAB NAME : ENGINEERING-SCIENCE, INC.
DATE ANALYZED : 03/04/93

LAB SAMPLE ID : MSVG3930304
DATE EXTRACTED : NA

MATRIX : SOIL
INSTRUMENT ID : VGC-3

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE ANALYZED
MSVG3930304	METHOD BLANK	03/04/93
SSVG3930403A	SPIKE	03/04/93
SSVG3930403B	SPIKE DUP	03/04/93
4840-1	JBG4.5'-5.0'	03/04/93
4840-2	JBG5.0'-5.5'	03/04/93

TOTAL RECOVERABLE PETROLEUM HYDROCARBONS
DATA PACKAGE

ES-ENGINEERING SCIENCE, INC.

600 Bancroft Way
Berkeley,CA 94710

ORGANIC ANALYTICAL REPORT

Work Order NO.: 4840

Parameter: TPH

Analytical Method: 418.1

QC Batch NO.: S93QCB013TPH

Matrix: Soil

Unit: mg/Kg

Date Extracted: 03/08/93

Date Analyzed: 03/11/93

Sample ID:	Client ID:	Result	Reporting Limit	Percent Moisture
4840-01	JBG4.5"-5.0"	70	12	15.5
4840-02	JBG5.0"-5.5"	16	11	13.1
4840-03	J1VW1-4.5"-5.0"	10000	11	10.7
4840-04	J1VW1-5"-5.5"	5300	11	11.3
4840-05	J2VW4.5"-5.0"	9300	10	11.0
4840-06	J2VW5.0"-5.5"	16800	11	10.3
4840-07	J3VW4.0"-4.5"	230	11	12.4
4840-08	J3VW4.5"-5.0"	300	11	12.5
MSTPH930308	METHOD BLANK	ND	10	NA

NA_ Not Analyzed
ND_ Not Detected

ANALYST: _____

GROUP LEADER: _____

ES-ENGINEERING SCIENCE, INC.

600 Bancroft Way
Berkeley. CA 94710

ORGANIC QUALITY CONTROL RESULTS SUMMARY
Blank Spike/Spike Duplicate

Work Order NO.: 4840

QC Sample NO.: SSTPH930226 A&B Analytical Method: 418.1

Blank I.D.: MSTPH930308 Matrix: Soil

QC Batch NO.: S93QCB013TPH Unit: mg/Kg

Parameter	Date Analyzed	BR	SA	BS	PR	BSD	PR	RPD
TPH	03/01/93	0	165	136	82	140	85	3

BS-Blank Spike
BSD-Blank Spike Duplicate
SA-Spike Added
BR_Blank Result
NA-Not Applicable
NC-Not Calculated
ND-Not Detected

RPD=((BS-BSD)/((BS+BSD)/2))*100

PR=((BS OR BSD -BR)/SA)*100

ANALYST:

QUALITY CONTROL:

METALS DATA PACKAGE

CASE NARRATIVE
WORK ORDER NO. 4840
METALS

Client ID's were abridged by the laboratory to facilitate computer entry of analytical data. The following should be used as a reference:

CLIENT ID	ABRIDGED ID
J1VW1-4.5'-5.0'	J1V5.0
J1VW1-5'-5.5'	J1V5.5
J2VW4.5'-5.0'	J2V5.0
J2VW5.0'-5.5'	J2V5.5
J3VW4.0'-4.5'	J3V4.5
J3VW4.5'-5.0'	J3V5.0
JBG5.5'-6.0'	JBG6.0
JBG6'-6.5'	JBG6.5

Engineering Science - Berkeley Laboratory
Inorganics Report

INORGANIC ANALYSES DATA SHEET

CLIENT SAMPLE ID: J1V5.0

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_____

Lab Code: ESBL__ Case No.: 4821S SAS No.: _____ SDG No.: JBG6.0

Matrix (soil/water): SOIL_ Lab Sample ID: 4840.03___

Level (low/med): LOW__ Date Sampled : 02/21/93

% Solids: _89.3

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7439-89-6	Iron	225			P

Comments:

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Engineering Science - Berkeley Laboratory
Inorganics Report

INORGANIC ANALYSES DATA SHEET

CLIENT SAMPLE ID

J1V5.5

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_____

Lab Code: ESBL__ Case No.: 4821S SAS No.: _____ SDG No.: JBG6.0

Matrix (soil/water): SOIL_ Lab Sample ID: 4840.04___

Level (low/med): LOW__ Date Sampled : 02/21/93

% Solids: _88.7

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7439-89-6	Iron	317			P

Comments:

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Inorganics Report

INORGANIC ANALYSES DATA SHEET

CLIENT SAMPLE ID

J2V5.0

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_____

Lab Code: ESBL__ Case No.: 4821S SAS No.: _____ SDG No.: JBG6.0

Matrix (soil/water): SOIL_ Lab Sample ID: 4840.05___

Level (low/med): LOW__ Date Sampled : 02/21/93

% Solids: _89.0

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7439-89-6	Iron	181			P

Comments:

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Engineering Science - Berkeley Laboratory
Inorganics Report

INORGANIC ANALYSES DATA SHEET

CLIENT SAMPLE ID

J2V5.5

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_____

Lab Code: ESBL__ Case No.: 4821S SAS No.: _____ SDG No.: JBG6.0

Matrix (soil/water): SOIL_ Lab Sample ID: 4840.06___

Level (low/med): LOW__ Date Sampled : 02/21/93

% Solids: _89.7

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7439-89-6	Iron	48.8			P

Comments:

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Engineering Science - Berkeley Laboratory
Inorganics Report

INORGANIC ANALYSES DATA SHEET

CLIENT SAMPLE ID: J3V4.5

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_____

Lab Code: ESBL__ Case No.: 4821S SAS No.: _____ SDG No.: JBG6.0

Matrix (soil/water): SOIL_ Lab Sample ID: 4840.07___

Level (low/med): LOW__ Date Sampled : 02/23/93

% Solids: _87.6

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7439-89-6	Iron	92.7			P

Comments:

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Engineering Science - Berkeley Laboratory
Inorganics Report

INORGANIC ANALYSES DATA SHEET

CLIENT SAMPLE ID: J3V5.0

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_____

Lab Code: ESBL__ Case No.: 4821S SAS No.: _____ SDG No.: JBG6.0

Matrix (soil/water): SOIL_ Lab Sample ID: 4840.08___

Level (low/med): LOW__ Date Sampled : 02/23/93

% Solids: _87.5

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7439-89-6	Iron	74.5			P

Comments:

Engineering Science - Berkeley Laboratory
Inorganics Report

INORGANIC ANALYSES DATA SHEET

CLIENT SAMPLE ID: JBG6.0

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_____

Lab Code: ESBL__ Case No.: 4821S SAS No.: _____ SDG No.: JBG6.0

Matrix (soil/water): SOIL_ Lab Sample ID: 4840.09___

Level (low/med): LOW__ Date Sampled : 02/21/93

% Solids: _82.5

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7439-89-6	Iron	351			P

FORM I - IN

3/90

Engineering Science - Berkeley Laboratory
Inorganics Report

INORGANIC ANALYSES DATA SHEET

CLIENT SAMPLE ID

JBG6.5

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_____

Lab Code: ESBL__ Case No.: 4821S SAS No.: _____ SDG No.: JBG6.0

Matrix (soil/water): SOIL_ Lab Sample ID: 4840.10___

Level (low/med): LOW__ Date Sampled : 02/21/93

% Solids: _86.1

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7439-89-6	Iron	414			P

Comments:

FORM I - IN

3/90

Engineering Science - Berkeley Laboratory
Inorganics Report

INORGANIC ANALYSES DATA SHEET

CLIENT SAMPLE ID: PBLANK

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_____

Lab Code: ESBL__ Case No.: 4821S SAS No.: _____ SDG No.: JBG6.0

Matrix (soil/water): SOIL_ Lab Sample ID: PB 502.21_

Level (low/med): LOW__ Date Sampled : 03/12/93

% Solids: 100.0

Concentration Units (ug/L or mg/kg dry weight): MG/KG

CAS No.	Analyte	Concentration	C	Q	M
7439-89-6	Iron	4.6	U		P

Comments:

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3/90

Engineering Science - Berkeley Laboratory
Inorganics Report

LABORATORY CONTROL SAMPLE (BLANK SPIKE)

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_____

Lab Code: ESBL__ Case No.: 4821S SAS No.: _____ SDG No.: JBG6.0

Solid LCS Source: ESBL-LCSS___

Aqueous LCS Source: _____

Analyte	Aqueous (ug/L) True	Found	%R	Solid (mg/kg) True	Found	C	Limits		%R
Iron				100.0	95.0		80.0	120.0	95.0

Engineering Science - Berkeley Laboratory
Inorganic Report

ICP SERIAL DILUTION

EPA SAMPLE NO.

VEW1-6L

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_____

Lab Code: ESBL__ Case No.: 4821S_ SAS No.: _____ SDG No.: JBG6.0

Matrix (soil/water): SOIL_ Level (low/med): LOW__

Concentration Units: ug/L

Analyte	Initial Sample Result (I)	C	Serial Dilution Result (S)	C	% Difference	Q	M
Iron	266015.80		289527.48		8.8		P

Engineering Science - Berkeley Laboratory

Method Detection Limits (Annually)

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_____

Lab Code: ESBL__ Case No.: 4821S_ SAS No.: _____ SDG No.: JBG6.0

ICP ID Number: TJA_61_____M Date: 08/31/92

Flame AA ID Number : _____ Matrix: SOIL_

Furnace AA ID Number : _____ (ug/L in 1.00g to 100ml digestate)

Analyte	Wave-length (nm)	Back-ground		MDL (ug/L)	M
Iron	271.44			46.0	P

Comments:

FORM X - IN ILM02

Engineering Science - Berkeley Laboratory
Inorganics Report

PREPARATION LOG

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_____

Lab Code: ESBL__ Case No.: _4821S_ SAS No.: _____ SDG No.: JBG6.0

Method: P_

EPA Sample No.	Preparation Date	Weight (gram)	Volume (mL)
J1V5.0	03/12/93	1.14	100
J1V5.5	03/12/93	1.16	100
J2V5.0	03/12/93	1.14	100
J2V5.5	03/12/93	1.13	100
J3V4.5	03/12/93	1.30	100
J3V5.0	03/12/93	1.13	100
JBG6.0	03/12/93	1.15	100
JBG6.5	03/12/93	1.37	100
LCSS	03/12/93	1.00	100
PBLANK	03/12/93	1.00	100
VEW1-6	03/12/93	1.06	100
VMP1-6	03/12/93	1.11	100
VMP2-6	03/12/93	1.17	100

Engineering Science - Berkeley Laboratory
Inorganics Report

ANALYSIS RUN LOG

Lab Name: E_S__BERKELEY_LABORATORY_ Contract: AFCEE_____

Lab Code: ESBL__ Case No.: 4821S_ SAS No.: _____ SDG No.: JBG6.0

Instrument ID Number: TJA 61 M_ Method: P_

Start Date: 03/12/93 End Date: 03/12/93

EPA Sample No.	D/F	Time	% R	Analytes FE
STD1	1.00	1539		X
STD2	1.00	1544		X
STD3	1.00	1549		X
STD4	1.00	1553		X
ICV	1.00	1558		X
ICB	1.00	1602		X
ICSA	1.00	1607		X
ICSAB	1.00	1612		X
CRI	1.00	1616		
PBLANK	1.00	1621		X
LCSS	1.00	1625		X
VEW1-6	1.00	1630		X
VEW1-6L	1.00	1635		X
VMP1-6	1.00	1639		X
VMP2-6	1.00	1644		X
J1V5.0	1.00	1648		X
CCV	1.00	1653		X
CCB	1.00	1658		X
J1V5.5	1.00	1702		X
J2V5.0	1.00	1707		X
J2V5.5	1.00	1711		X
J3V4.5	1.00	1716		X
J3V5.0	1.00	1721		X
JBG6.0	1.00	1725		X
JBG6.5	1.00	1730		X
ICSA	1.00	1734		X
ICSAB	1.00	1739		X
CRI	1.00	1744		
CCV	1.00	1748		X
CCB	1.00	1753		X

INORGANICS DATA PACKAGE

ES-ENGINEERING-SCIENCE, INC.
600 Bancroft Way
Berkeley, CA 94710

INORGANICS ANALYTICAL REPORT

Client: ES-Denver
Project: AFCEE

Work Order: 4840
Matrix: Solid

Client's ID:	J1VW1 -4.5'-5.0'	J1VW1 -5'-5.5'	J2VW -4.5'-5.0'				
Sample Date:	02/21/93	02/21/93	02/21/93				
% Moisture:							
Lab ID:	4840.03	4840.04	4840.05				
Parameter	Results			Method	Normal Report Limit	Units	Date Analyzed
Alkalinity	670.	410.	390.	SM 403(M)	50	mg/Kg CaCO3	03/12/93
Moisture	10.7	11.3	11.0	ASTM D2216	.1	% by wt	03/02/93
pH	8.9	8.9	9.0	EPA 9045	NA	pH Units	03/12/93

Note: Samples for alkalinity analysis were extracted using 10mL water for each 1g sample. These water extracts were analyzed for alkalinity, and the results were calculated in the solid on a dry-weight basis.

NA- Not Applicable
ND- Not Detected

ANALYST: Don Sleaton

GROUP LEADER:

ES-ENGINEERING-SCIENCE, INC.

600 Bancroft Way
Berkeley, CA 94710

INORGANIC QC SUMMARY - MS and MSD

Work Order: 4840

% Moisture: NA

	Alkalinity	Moisture	pH
Lab ID Spk/Dup:	Blank Spk	4838.01	4840.03
QC Batch:	452.52	489.40	452.62

Matrix: Solid

Units: mg/Kg CaCO3 (Alk)
% by wt. (Mois)
pH Units (pH)

Parameter	Date Analyzed MS/Dup	Unspiked Sample	MS/Sample	MSD/Dup	RPD	RPD QC Limit	-Conc Added- MS	MSD	Percent Recovered MS	MSD
Alkalinity	03/12/93	0.00	23500.00	23500.00	0	20	23650.00	23650.00	99	99
Moisture	03/02/93		26.38	28.34	7	20				
pH	03/12/93		8.87	8.88	0	20				

* or N = Outside QC Limit:

QC Limits for % Rec: 75 - 125

ANALYST: Don Gleaton Date 03/16/93 REVIEWER: MM3 Date 3/16/93

File:M1QCMSWM

ES-ENGINEERING-SCIENCE, INC.

600 Bancroft Way
Berkeley, CA 94710

INORGANICS ANALYTICAL REPORT

Client: ES-Denver
Project: AFCEE

Work Order: 4840
Matrix: Solid

Client's ID:	J2VW -5.0'-5.5'	J3VW -4.0'-4.5'	J3VW -4.5'-5.0'
Sample Date:	02/21/93	02/23/93	02/23/93
% Moisture:			
Lab ID:	4840.06	4840.07	4840.08

Parameter	Results			Method	Normal Report Limit	Units	Date Analyzed
Alkalinity	420.	340.	370.	SM 403(M)	50	mg/Kg CaCO3	03/12/93
Moisture	10.3	12.4	12.5	ASTM D2216	.1	% by wt	03/02/93
pH	8.9	8.9	9.1	EPA 9045	NA	pH Units	03/12/93

Note: Samples for alkalinity analysis were extracted using 10mL water for each 1g sample. These water extracts were analyzed for alkalinity, and the results were calculated in the solid on a dry-weight basis.

NA- Not Applicable
ND- Not Detected

ANALYST: Don Sleator

GROUP LEADER:

ES-ENGINEERING-SCIENCE, INC.

600 Bancroft Way
Berkeley, CA 94710

INORGANICS ANALYTICAL REPORT

Client: ES-Denver
Project: AFCEE

Work Order: 4840
Matrix: Solid

Client's ID:	JBG -5.5'-6.0'	JBG -6'-6.5'	Method	Normal Report Limit	Units	Date Analyzed
Sample Date:	02/21/93	02/21/93				
% Moisture:						
Lab ID:	4840.09	4840.10				
Parameter	----------Results----------					
Alkalinity	360.	370.	SM 403(M)	50	mg/Kg CaCO3	03/12/93
Moisture	17.5	13.9	ASTM D2216	.1	% by wt	03/02/93
pH	8.9	9.0	EPA 9045	NA	pH Units	03/12/93

Note: Samples for alkalinity analysis were extracted using 10mL water for each 1g sample. These water extracts were analyzed for alkalinity, and the results were calculated in the solid on a dry-weight basis.

NA- Not Applicable
ND- Not Detected

ANALYST: Don Gleaton

GROUP LEADER: [signature]

ES-ENGINEERING-SCIENCE, INC.

600 Bancroft Way
Berkeley, CA 94710

INORGANICS ANALYTICAL REPORT

Client: ES-Denver
Project: AFCEE

Work Order: 4840
Matrix: Solid

Client's ID: Prep Blank

Sample Date:
% Moisture:
Lab ID: Prep Blank

Parameter	Results	Method	Normal Report Limit	Units	Date Analyzed
Alkalinity	ND	SM 403(M)	50	mg/Kg CaCO3	03/12/93
Moisture	NA	ASTM D2216	.1	% by wt	03/02/93
pH	NA	EPA 9045	NA	pH Units	03/12/93

Note: Samples for alkalinity analysis were extracted using 10mL water for each 1g sample. These water extracts were analyzed for alkalinity, and the results were calculated in the solid on a dry-weight basis.

NA- Not Applicable
ND- Not Detected

ANALYST: Don Gleaton

GROUP LEADER:

TOTAL PHOSPHORUS

TOTAL KJELDAHL NITROGEN

SOIL CLASSIFICATION

DATA PACKAGE

SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.	Client Project ID:	W.O. 4840	Sampled:	Feb 21, 1993
600 Bancroft Way	Sample Descript:	Soil	Received:	Mar 1, 1993
Berkeley, CA 94710	Analysis for:	Total Kjeldahl Nitrogen		
Attention: Tom Paulson	First Sample #:	3C02601	Analyzed:	Mar 11, 1993
			Reported:	Mar 15, 1993

LABORATORY ANALYSIS FOR: Total Kjeldahl Nitrogen

Sample Number	Sample Description	Detection Limit mg/kg	Sample Result mg/kg
3C02601	4840-3C (J1-VW1-4.5'-5.0')	20	440
3C02602	4840-4C (J1-VW1-5'-5.5')	20	440
3C02603	4840-5C (J2-VW-4.5'-5.0')	20	200
3C02604	4840-6C (J2-VW-5.0'-5.5')	20	170
3C02605	4840-7C (J3-VW-4.0'-4.5')	20	140
3C02606	4840-8C (J3-VW-4.5'-5.0')	20	140
3C02607	4840-9B (JB6-5.5'-6.0')	20	140
3C02608	4840-10B (J-BG-6'-6.5')	20	260
	Method Blank	20	N.D.

THIS REPORT HAS BEEN APPROVED AND REVIEWED BY

3/17/93

ESBL PROJECT MANAGER / DATE

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL

Jennifer A. Nelson
Project Manager

Please Note:
Sample results reported on dry weight basis.

SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.	Client Project ID:	W.O. 4840	Sampled:	Feb 21, 1993
600 Bancroft Way	Sample Descript:	Soil	Received:	Mar 1, 1993
Berkeley, CA 94710	Analysis for:	Phosphorus		
Attention: Tom Paulson	First Sample #:	3C02601	Analyzed:	Mar 11, 1993
			Reported:	Mar 15, 1993

LABORATORY ANALYSIS FOR: Phosphorus

Sample Number	Sample Description	Detection Limit mg/kg	Sample Result mg/kg
3C02601	4840-3C (J1-VW1-4.5'-5.0')	1.0	330
3C02602	4840-4C (J1-VW1-5'-5.5')	1.0	410
3C02603	4840-5C (J2-VW-4.5'-5.0')	1.0	510
3C02604	4840-6C (J2-VW-5.0'-5.5')	1.0	530
3C02605	4840-7C (J3-VW-4.0'-4.5')	1.0	320
3C02606	4840-8C (J3-VW-4.5'-5.0')	1.0	360
3C02607	4840-9B (JB6-5.5'-6.0')	1.0	270
3C02608	4840-10B (J-BG-6'-6.5')	1.0	310
	Method Blank	1.0	N.D.

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL

Jennifer A. Nelson
Project Manager

Please Note:
Sample results reported on dry weight basis.

SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.	Client Project ID:	W.O. 4840	Sampled:	Feb 21, 1993
600 Bancroft Way	Sample Descript:	Soil	Received:	Mar 1, 1993
Berkeley, CA 94710	Analysis for:	Total Solids		
Attention: Tom Paulson	First Sample #:	3C02601	Analyzed:	Mar 3, 1993
			Reported:	Mar 15, 1993

LABORATORY ANALYSIS FOR: Total Solids

Sample Number	Sample Description	Detection Limit %	Sample Result %
3C02601	4840-3C (J1-VW1-4.5'-5.0')	1.0	90
3C02602	4840-4C (J1-VW1-5'-5.5')	1.0	90
3C02603	4840-5C (J2-VW-4.5'-5.0')	1.0	90
3C02604	4840-6C (J2-VW-5.0'-5.5')	1.0	90
3C02605	4840-7C (J3-VW-4.0'-4.5')	1.0	88
3C02606	4840-8C (J3-VW-4.5'-5.0')	1.0	88
3C02607	4840-9B (JB6-5.5'-6.0')	1.0	86
3C02608	4840-10B (J-BG-6'-6.5')	1.0	86

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL

Jennifer A. Nelson
Project Manager

SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.	Client Project ID:	W.O. 4840
600 Bancroft Way	Matrix:	Soil
Berkeley, CA 94710		
Attention: Tom Paulson	QC Sample Group: 3C02601-08	Reported: Mar 15, 1993

QUALITY CONTROL DATA REPORT

ANALYTE	Total Kjeldahl Nitrogen	Phosphorus
Method:	EPA 351.4	EPA 365.3
Analyst:	N. Northey	K. Follett
Concentration Spiked:	100	100
LCS Batch#:	N.A.	N.A.
Date Prepared:	3/10/93	3/11/93
Date Analyzed	3/10/93	3/11/93
Instrument I.D.#:	N.A.	N.A.
LCS % Recovery:	96	80
Control Limits:	80 - 120%	80 - 120%
MS/MSD Batch #:	9303026-1A	9303026-1A
Date Prepared:	3/10/93	3/11/93
Date Analyzed	3/10/93	3/11/93
Instrument I.D.#:	N.A.	N.A.
Matrix Spike % Recovery:	105	90
Matrix Spike Duplicate % Recovery:	105	100
Relative % Difference:	0.0	2.5

Please Note:
The LCS is a control sample of known, interferent free matrix that is analyzed using the same reagents, preparation and analytical methods employed for the samples. The LCS % recovery data is used for validation of sample batch results. Due to matrix effects, the QC limits for MS/MSD's are advisory only and are not used to accept or reject batch results.

SEQUOIA ANALYTICAL

Jennifer A. Nelson
Project Manager

SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.	Client Project ID: W.O. 4840	
600 Bancroft Way	Matrix: Soil	
Berkeley, CA 94710		
Attention: Tom Paulson	QC Sample Goup: 3C02601-08	Reported: Mar 15, 1993

QUALITY CONTROL DATA REPORT

ANALYTE	Total Solids

Method:	EPA 160.3
Analyst:	Y. Arteaga
Date:	3/3/93
Sample #:	9303026-06A
Sample Concentration:	88
Sample Duplicate Concentration:	87
% RPD:	1.1
Control Limits:	80 - 120%

SEQUOIA ANALYTICAL

Jennifer A. Nelson

Jennifer A. Nelson
Project Manager

SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.	Client Project ID:	W.O. 4840	Sampled:	Feb 21, 1993
600 Bancroft Way	Sample Descript:	Soil, J1-VW1-4.5'-5.0'	Received:	Mar 1, 1993
Berkeley, CA 94710	Method of Analysis:	ASTM D422-63	Analyzed:	Mar 8, 1993
Attention: Tom Paulson	Lab Number:	3C02601	Reported:	Mar 15, 1993

PARTICLE SIZE DISTRIBUTION BY SIEVE AND HYDROMETER

SIEVE TEST

(A) TOTAL WEIGHT OF SAMPLE:	323.98g
(B) WEIGHT RETAINED IN NO. 10 SIEVE:	180.34g
(C) % PASSING NO. 10 SIEVE:	55.66

SIEVE TEST FOR WEIGHT RETAINED IN NO. 10 SIEVE

IDEAL PAN = 0.0
IDEAL TOTAL = (B)

SIEVE SIZE	WEIGHT RETAINED, g	% RETAINED	CUMULATIVE % RETAINED	CUMULATIVE % PASSING
1½ in.	0.0	0.0	0.0	100
3/8 in.	60.53	18.68	18.68	81.32
No. 4	59.79	18.45	37.13	62.87
No. 10	60.02	18.53	55.66	44.34
No. 200	101.38	31.29	86.95	13.05
PAN				
TOTAL				

HYDROMETER TEST

ELAPSED TIME (T)	TEMP. °C	HYDROMETER READING (H)	CORRECTED READING (R)	(L)	PARTICLE DIAM. (S)	% SUSPENDED (P)
2	22	30	26	12.0	0.032	12.81
5	22	27	23	12.5	0.021	11.34
10	22	25	21	12.9	0.015	10.35
15	22	23	19	13.2	0.012	9.36
25	22	22	18	13.3	0.0097	8.87
40	22	20	16	13.7	0.0078	7.89
60	22	19	15	13.8	0.0064	7.39
90	22	19	15	13.8	0.0052	7.39
120	22	18	14	14.0	0.0045	6.90
1440	22	12	8.0	15.0	0.0014	3.94

WEIGHT OF SOIL USED IN HYDROMETER TEST (D):	115g
HYGROSCOPIC MOISTURE CORRECTION FACTOR (G):	0.982
SPECIFIC GRAVITY (ASSUMED):	2.65
DISPERSING AGENT CORRECTION FACTOR (E):	3.0
MENISCUS CORRECTION FACTOR (F):	1.0
TEMP./SPEC. GRAVITY DEPENDANT CONSTANT (K):	0.01332

FORMULAS:

$R = H - E - F$

$S = K [SQRT (L / T)]$

$P = (R / W) 100$

$W = (J \cdot 100) / C$

$J = D \cdot G$

SEQUOIA ANALYTICAL

Jennifer A. Nelson
Project Manager

SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.	Client Project ID:	W.O. 4840	Sampled:	Feb 21, 1993
600 Bancroft Way	Sample Descript:	Soil, J1-VW1-5'-5.5'	Received:	Mar 1, 1993
Berkeley, CA 94710	Method of Analysis:	ASTM D422-63	Analyzed:	Mar 8, 1993
Attention: Tom Paulson	Lab Number:	3C02602	Reported:	Mar 15, 1993

PARTICLE SIZE DISTRIBUTION BY SIEVE AND HYDROMETER

SIEVE TEST

(A) TOTAL WEIGHT OF SAMPLE:	402.07g
(B) WEIGHT RETAINED IN NO. 10 SIEVE:	287.07g
(C) % PASSING NO. 10 SIEVE:	28.60

SIEVE TEST FOR WEIGHT RETAINED IN NO. 10 SIEVE

SIEVE SIZE	WEIGHT RETAINED, g	% RETAINED	CUMULATIVE % RETAINED	CUMULATIVE % PASSING
1½ in.	0.0	0.0	0.0	100
3/8 in.	94.37	23.47	23.47	76.53
No. 4	109.84	27.32	50.79	49.21
No. 10	82.86	20.61	71.4	28.60
No. 200	85.88	21.36	92.76	7.24
PAN				
TOTAL				

IDEAL PAN = 0.0
IDEAL TOTAL = (B)

HYDROMETER TEST

ELAPSED TIME (T)	TEMP. °C	HYDROMETER READING (H)	CORRECTED READING (R)	(L)	PARTICLE DIAM. (S)	% SUSPENDED (P)
2	22	27	23	12.50	0.033	5.73
5	22	25	21	12.9	0.021	5.23
10	22	22	18	13.3	0.015	4.49
15	22	21	17	13.5	0.013	4.24
25	22	20	16	13.7	0.0099	3.99
40	22	18	14	14.0	0.0079	3.49
60	22	17	13	14.2	0.0065	3.24
90	22	16	12	14.3	0.0053	2.99
120	22	15	11	14.5	0.0046	2.74
1440	22	11	7.0	15.2	0.0014	1.74

WEIGHT OF SOIL USED IN HYDROMETER TEST (D):	115g
HYGROSCOPIC MOISTURE CORRECTION FACTOR (G):	0.998
SPECIFIC GRAVITY (ASSUMED):	2.65
DISPERSING AGENT CORRECTION FACTOR (E):	3.0
MENISCUS CORRECTION FACTOR (F):	1.0
TEMP./SPEC. GRAVITY DEPENDANT CONSTANT (K):	0.01332

FORMULAS:
R = H - E - F
S = K [SQRT (L / T)]
P = (R / W) 100
W = (J · 100) / C
J = D · G

SEQUOIA ANALYTICAL

Jennifer A. Nelson
Project Manager

SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.	Client Project ID:	W.O. 4840	Sampled:	Feb 21, 1993
600 Bancroft Way	Sample Descript:	Soil, J2-VW-4.5'-5.0'	Received:	Mar 1, 1993
Berkeley, CA 94710	Method of Analysis:	ASTM D422-63	Analyzed:	Mar 8, 1993
Attention: Tom Paulson	Lab Number:	3C02603	Reported:	Mar 15, 1993

PARTICLE SIZE DISTRIBUTION BY SIEVE AND HYDROMETER

SIEVE TEST

(A) TOTAL WEIGHT OF SAMPLE:	327.53g
(B) WEIGHT RETAINED IN NO. 10 SIEVE:	195.16g
(C) % PASSING NO. 10 SIEVE:	40.41

SIEVE TEST FOR WEIGHT RETAINED IN NO. 10 SIEVE

IDEAL PAN = 0.0
IDEAL TOTAL = (B)

SIEVE SIZE	WEIGHT RETAINED, g	% RETAINED	CUMULATIVE % RETAINED	CUMULATIVE % PASSING
1½ in.	0.0	0.0	0.0	100
3/8 in.	85.28	26.04	26.04	73.96
No. 4	60.98	18.62	44.66	55.34
No. 10	48.90	14.93	59.59	40.41
No. 200	94.90	28.98	88.57	11.43
PAN				
TOTAL				

HYDROMETER TEST

ELAPSED TIME (T)	TEMP. °C	HYDROMETER READING (H)	CORRECTED READING (R)	(L)	PARTICLE DIAM. (S)	% SUSPENDED (P)
2	22	28	24	12.4	0.033	8.57
5	22	26	22	12.7	0.021	7.86
10	22	24	20	13.0	0.015	7.14
15	22	23	19	13.2	1.012	6.78
25	22	22	18	13.3	0.0097	6.43
40	22	21	17	13.5	0.0077	6.07
60	22	20	16	13.7	0.0064	5.71
90	22	19	15	13.8	0.0052	5.36
120	22	19	15	13.8	0.0045	5.36
1440	22	16	12	14.3	0.0013	4.29

WEIGHT OF SOIL USED IN HYDROMETER TEST (D):	115g
HYGROSCOPIC MOISTURE CORRECTION FACTOR (G):	0.984
SPECIFIC GRAVITY (ASSUMED):	2.65
DISPERSING AGENT CORRECTION FACTOR (E):	3.0
MENISCUS CORRECTION FACTOR (F):	1.0
TEMP./SPEC. GRAVITY DEPENDANT CONSTANT (K):	0.01332

FORMULAS:

$R = H - E - F$

$S = K [SQRT (L / T)]$

$P = (R / W) 100$

$W = (J \cdot 100) / C$

$J = D \cdot G$

SEQUOIA ANALYTICAL

Jennifer A. Nelson
Project Manager

SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.	Client Project ID:	W.O. 4840	Sampled:	Feb 21, 1993
600 Bancroft Way	Sample Descript:	Soil, J2-VW-5.0'-5.5'	Received:	Mar 1, 1993
Berkeley, CA 94710	Method of Analysis:	ASTM D422-63	Analyzed:	Mar 9, 1993
Attention: Tom Paulson	Lab Number:	3C02604	Reported:	Mar 15, 1993

PARTICLE SIZE DISTRIBUTION BY SIEVE AND HYDROMETER

SIEVE TEST

(A) TOTAL WEIGHT OF SAMPLE:	268.59g
(B) WEIGHT RETAINED IN NO. 10 SIEVE:	138.29g
(C) % PASSING NO. 10 SIEVE:	48.51

SIEVE TEST FOR WEIGHT RETAINED IN NO. 10 SIEVE

SIEVE SIZE	WEIGHT RETAINED, g	% RETAINED	CUMULATIVE % RETAINED	CUMULATIVE % PASSING
1½ in.	0.0	0.0	0.0	100
3/8 in.	51.52	19.18	19.18	80.82
No. 4	51.69	19.24	39.42	60.58
No. 10	35.08	13.06	52.48	47.52
No. 200	92.03	34.26	86.74	13.26
PAN				
TOTAL				

IDEAL PAN = 0.0
IDEAL TOTAL = (B)

HYDROMETER TEST

ELAPSED TIME (T)	TEMP. °C	HYDROMETER READING (H)	CORRECTED READING (R)	(L)	PARTICLE DIAM. (S)	% SUSPENDED (P)
2	21	30	26	12.0	0.033	11.11
5	21	28	24	12.4	0.021	10.26
10	21	25	21	12.9	0.015	8.98
15	21	24	20	13.0	0.013	8.55
25	21	22	18	13.3	0.0098	7.69
40	21	21	17	13.5	0.0078	7.27
60	21	20	16	13.7	0.0064	6.83
90	21	19	15	13.8	0.0053	6.41
120	21	19	15	13.8	0.0046	6.41
1440	21	17	13	14.2	0.0013	5.56

WEIGHT OF SOIL USED IN HYDROMETER TEST (D):	115g
HYGROSCOPIC MOISTURE CORRECTION FACTOR (G):	0.987
SPECIFIC GRAVITY (ASSUMED):	2.65
DISPERSING AGENT CORRECTION FACTOR (E):	3.0
MENISCUS CORRECTION FACTOR (F):	1.0
TEMP./SPEC. GRAVITY DEPENDANT CONSTANT (K):	0.01348

FORMULAS:

$R = H - E - F$

$S = K [SQRT (L / T)]$

$P = (R / W) 100$

$W = (J \cdot 100) / C$

$J = D \cdot G$

SEQUOIA ANALYTICAL

Jennifer A. Nelson
Project Manager

SEQUOIA ANALYTICAL

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(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.	Client Project ID:	W.O. 4840	Sampled:	Feb 21, 1993
600 Bancroft Way	Sample Descript:	Soil, J3-VW-4.0'-4.5'	Received:	Mar 1, 1993
Berkeley, CA 94710	Method of Analysis:	ASTM D422-63	Analyzed:	Mar 9, 1993
Attention: Tom Paulson	Lab Number:	3C02605	Reported:	Mar 15, 1993

PARTICLE SIZE DISTRIBUTION BY SIEVE AND HYDROMETER

SIEVE TEST

(A) TOTAL WEIGHT OF SAMPLE:	410.93g
(B) WEIGHT RETAINED IN NO. 10 SIEVE:	214.68g
(C) % PASSING NO. 10 SIEVE:	47.76

SIEVE TEST FOR WEIGHT RETAINED IN NO. 10 SIEVE

SIEVE SIZE	WEIGHT RETAINED, g	% RETAINED	CUMULATIVE % RETAINED	CUMULATIVE % PASSING
1½ in.	0.0	0.0	0.0	100
3/8 in.	41.69	10.15	10.15	89.85
No. 4	79.01	19.23	29.38	70.62
No. 10	93.98	22.87	52.25	47.75
No. 200	147.67	35.93	88.18	11.82
PAN				
TOTAL				

IDEAL PAN = 0.0
IDEAL TOTAL = (B)

HYDROMETER TEST

ELAPSED TIME (T)	TEMP. °C	HYDROMETER READING (H)	CORRECTED READING (R)	(L)	PARTICLE DIAM. (S)	% SUSPENDED (P)
2	21	30	26	12.0	0.033	10.83
5	21	27	23	12.5	0.021	9.58
10	21	26	22	12.7	0.015	9.16
15	21	25	21	12.9	0.013	8.75
25	21	24	20	13	0.0097	8.33
40	21	23	19	13.2	0.0077	7.91
60	21	22	18	13.3	0.0063	7.5
90	21	22	18	13.3	0.0052	7.5
120	21	20	16	13.7	0.0046	6.66
1440	21	18	14	14.0	0.0013	5.83

WEIGHT OF SOIL USED IN HYDROMETER TEST (D):	115g
HYGROSCOPIC MOISTURE CORRECTION FACTOR (G):	0.997
SPECIFIC GRAVITY (ASSUMED):	2.65
DISPERSING AGENT CORRECTION FACTOR (E):	3.0
MENISCUS CORRECTION FACTOR (F):	1.0
TEMP./SPEC. GRAVITY DEPENDANT CONSTANT (K):	0.01348

FORMULAS:

$R = H - E - F$

$S = K [SQRT (L / T)]$

$P = (R / W) 100$

$W = (J \cdot 100) / C$

$J = D \cdot G$

SEQUOIA ANALYTICAL

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Project Manager

SEQUOIA ANALYTICAL

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Engineering Science, Inc.	Client Project ID:	W.O. 4840	Sampled:	Feb 21, 1993
600 Bancroft Way	Sample Descript:	Soil, J3-VW-4.5'-5.0'	Received:	Mar 1, 1993
Berkeley, CA 94710	Method of Analysis:	ASTM D422-63	Analyzed:	Mar 9, 1993
Attention: Tom Paulson	Lab Number:	3C02606	Reported:	Mar 15, 1993

PARTICLE SIZE DISTRIBUTION BY SIEVE AND HYDROMETER

SIEVE TEST

(A) TOTAL WEIGHT OF SAMPLE:	315.37g
(B) WEIGHT RETAINED IN NO. 10 SIEVE:	144.22g
(C) % PASSING NO. 10 SIEVE:	54.27

SIEVE TEST FOR WEIGHT RETAINED IN NO. 10 SIEVE

SIEVE SIZE	WEIGHT RETAINED, g	% RETAINED	CUMULATIVE % RETAINED	CUMULATIVE % PASSING
1½ in.	0.0	0.0	0.0	100
3/8 in.	25.54	8.09	8.09	91.91
No. 4	53.63	17.01	25.1	74.9
No. 10	65.05	20.63	45.73	54.27
No. 200	124	39.32	85.05	14.95
PAN				
TOTAL				

IDEAL PAN = 0.0
IDEAL TOTAL = (B)

HYDROMETER TEST

ELAPSED TIME (T)	TEMP. °C	HYDROMETER READING (H)	CORRECTED READING (R)	(L)	PARTICLE DIAM. (S)	% SUSPENDED (P)
2	21	32	28	11.7	0.033	12.75
5	21	30	26	12.0	0.021	11.38
10	21	27	23	12.5	0.015	10.07
15	21	27	23	12.5	0.012	10.07
25	21	26	22	12.7	0.0096	9.63
40	21	25	21	12.9	0.0077	9.19
60	21	24	20	13	0.0063	8.75
90	21	23	19	13.2	0.0052	8.32
120	21	23	19	13.2	0.0045	8.32
1440	21	19	15	13.8	0.0013	6.56

WEIGHT OF SOIL USED IN HYDROMETER TEST (D):	115g
HYGROSCOPIC MOISTURE CORRECTION FACTOR (G):	0.996
SPECIFIC GRAVITY (ASSUMED):	2.65
DISPERSING AGENT CORRECTION FACTOR (E):	3.0
MENISCUS CORRECTION FACTOR (F):	1.0
TEMP./SPEC. GRAVITY DEPENDANT CONSTANT (K):	0.01348

FORMULAS:

$R = H - E - F$

$S = K [SQRT (L / T)]$

$P = (R / W) 100$

$W = (J \cdot 100) / C$

$J = D \cdot G$

SEQUOIA ANALYTICAL

Jennifer A. Nelson
Project Manager

SEQUOIA ANALYTICAL

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(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.	Client Project ID:	W.O. 4840	Sampled: Feb 21, 1993
600 Bancroft Way	Sample Descript:	Soil, J-BG-5.5'-6.0', JBG-6'-6.5'	Received: Mar 1, 1993
Berkeley, CA 94710	Method of Analysis:	ASTM D422-63	Analyzed: Mar 11, 1993
Attention: Tom Paulson	Lab Number:	3C02607, 08 composite	Reported: Mar 15, 1993

PARTICLE SIZE DISTRIBUTION BY SIEVE AND HYDROMETER

SIEVE TEST

(A) TOTAL WEIGHT OF SAMPLE:	244.29g
(B) WEIGHT RETAINED IN NO. 10 SIEVE:	116.45g
(C) % PASSING NO. 10 SIEVE:	52.33

SIEVE TEST FOR WEIGHT RETAINED IN NO. 10 SIEVE

SIEVE SIZE	WEIGHT RETAINED, g	% RETAINED	CUMULATIVE % RETAINED	CUMULATIVE % PASSING
1½ in.	0.0	0.0	0.0	100
3/8 in.	38.32	15.69	15.69	84.31
No. 4	35.91	14.7	30.39	69.61
No. 10	42.22	17.28	47.67	52.33
No. 200	90.62	37.10	84.77	15.23
PAN				
TOTAL				

IDEAL PAN = 0.0
IDEAL TOTAL = (B)

HYDROMETER TEST

ELAPSED TIME (T)	TEMP. °C	HYDROMETER READING (H)	CORRECTED READING (R)	(L)	PARTICLE DIAM. (S)	% SUSPENDED (P)
2	21	30	26	12.0	0.033	11.83
5	21	24	20	13.0	0.022	9.1
10	21	22	18	13.3	0.016	8.2
15	21	21	17	13.5	0.013	7.74
25	21	20	16	13.7	0.0099	7.28
40	21	18	14	14.0	0.008	6.37
60	21	18	14	14.0	0.0065	6.37
90	21	17	13	14.2	0.0054	5.92
120	21	16	12	14.3	0.0047	5.46
1440	21	13	9	14.8	0.0014	4.10

WEIGHT OF SOIL USED IN HYDROMETER TEST (D):	115g
HYGROSCOPIC MOISTURE CORRECTION FACTOR (G):	1.00
SPECIFIC GRAVITY (ASSUMED):	2.65
DISPERSING AGENT CORRECTION FACTOR (E):	3.0
MENISCUS CORRECTION FACTOR (F):	1.0
TEMP./SPEC. GRAVITY DEPENDANT CONSTANT (K):	0.01348

FORMULAS:

$R = H - E - F$

$S = K [SQRT (L / T)]$

$P = (R / W) 100$

$W = (J \cdot 100) / C$

$J = D \cdot G$

SEQUOIA ANALYTICAL

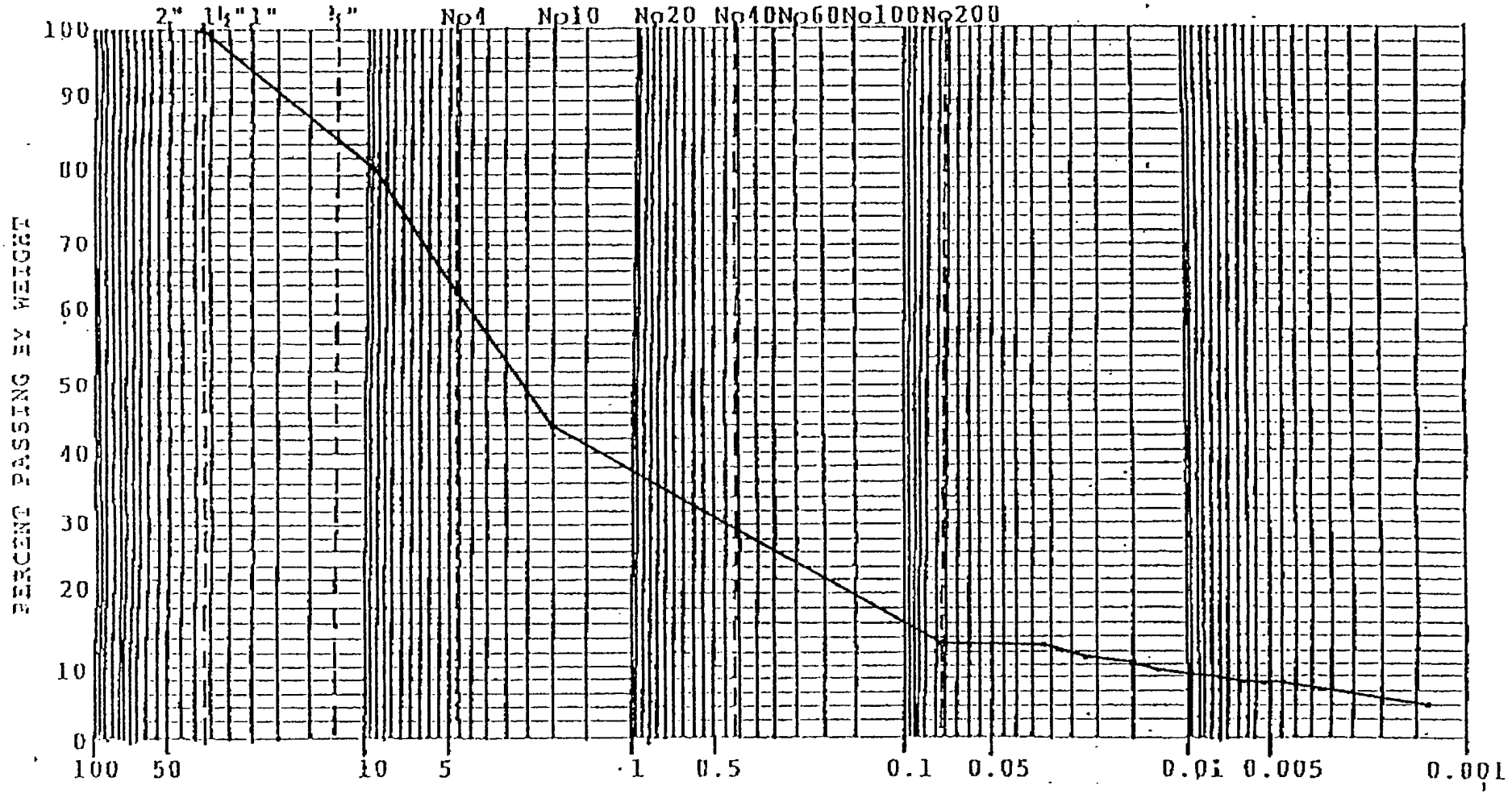
Jennifer A. Nelson
Project Manager

SAMPLE DESCRIPTION: Engineering Science

LABORATORY NUMBER: 9303026-1A

SAND	30%
SILT	8%
CLAY	5%

U.S. STANDARD SIEVE SIZES



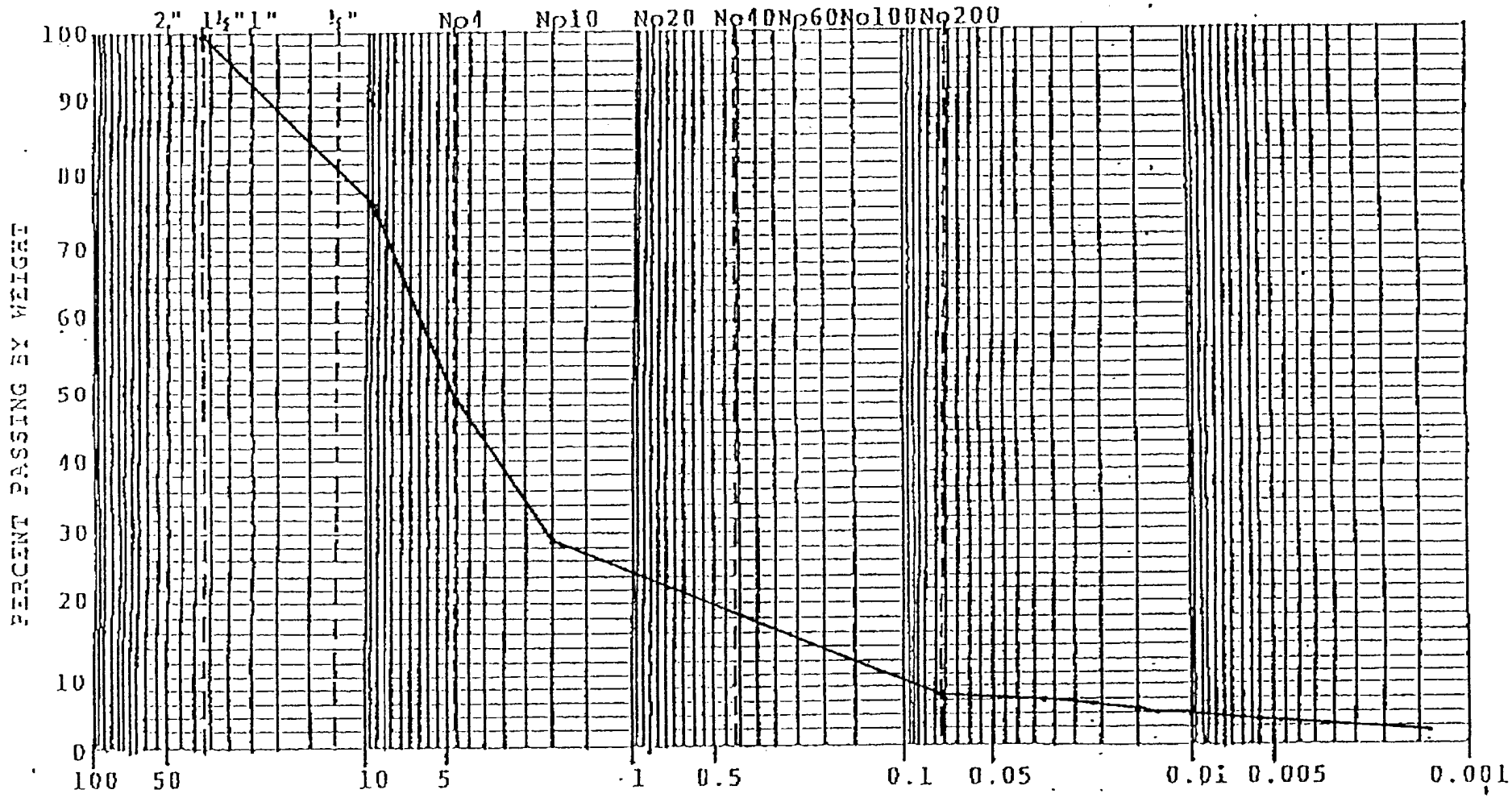
COBBLES	COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES	
	GRAVEL		SAND			FINES		

SAMPLE DESCRIPTION: Engineering Science

LABORATORY NUMBER: 9303026-2A

SILT	75%
CLAY	23%

U.S. STANDARD SIEVE SIZES

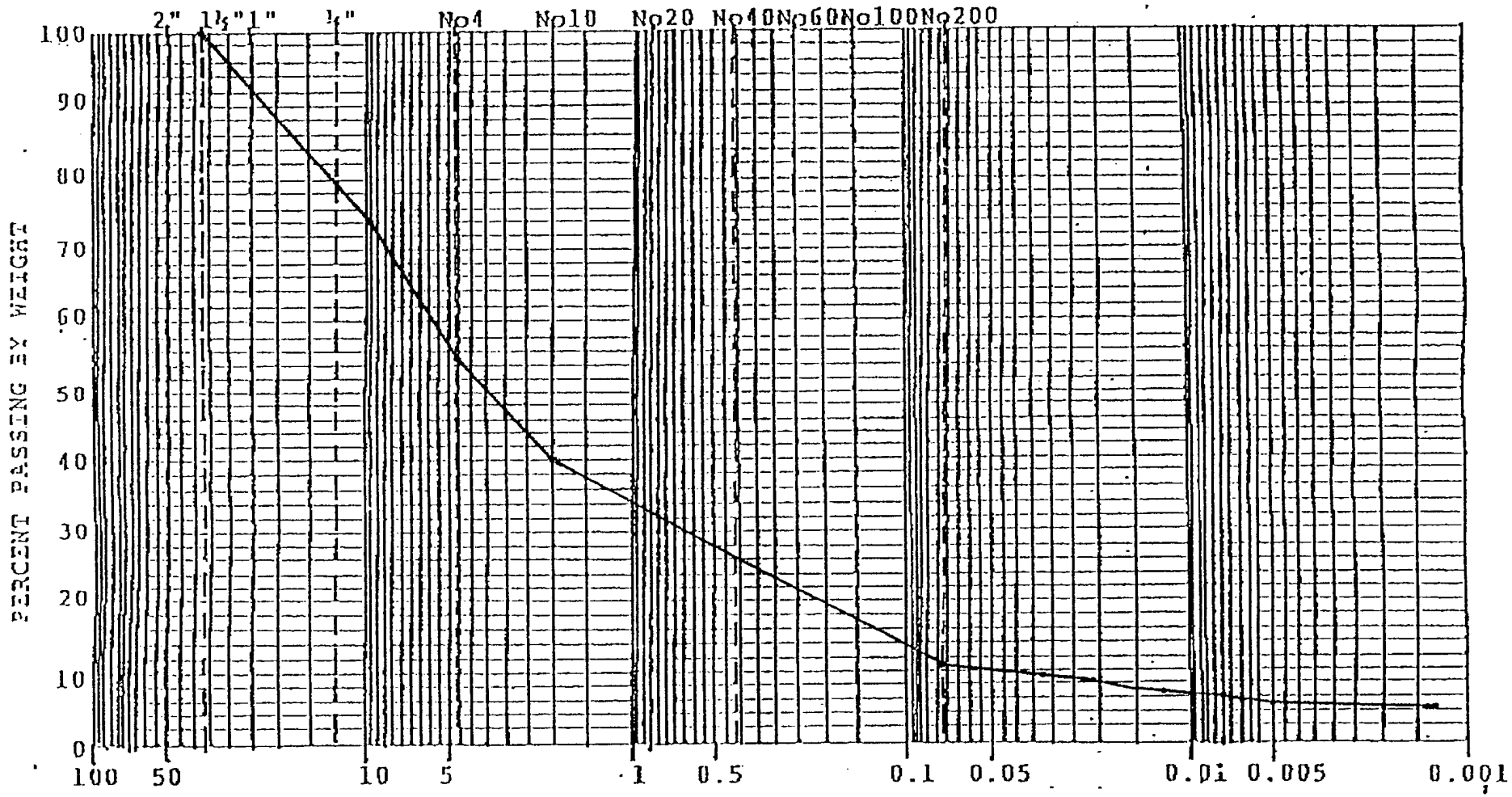


COBBLES	COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES	
	GRAVEL		SAND			FINES		

LABORATORY NUMBER: 9303026-3A

[redacted]	[redacted]
CLAY	5%

U.S. STANDARD SIEVE SIZES



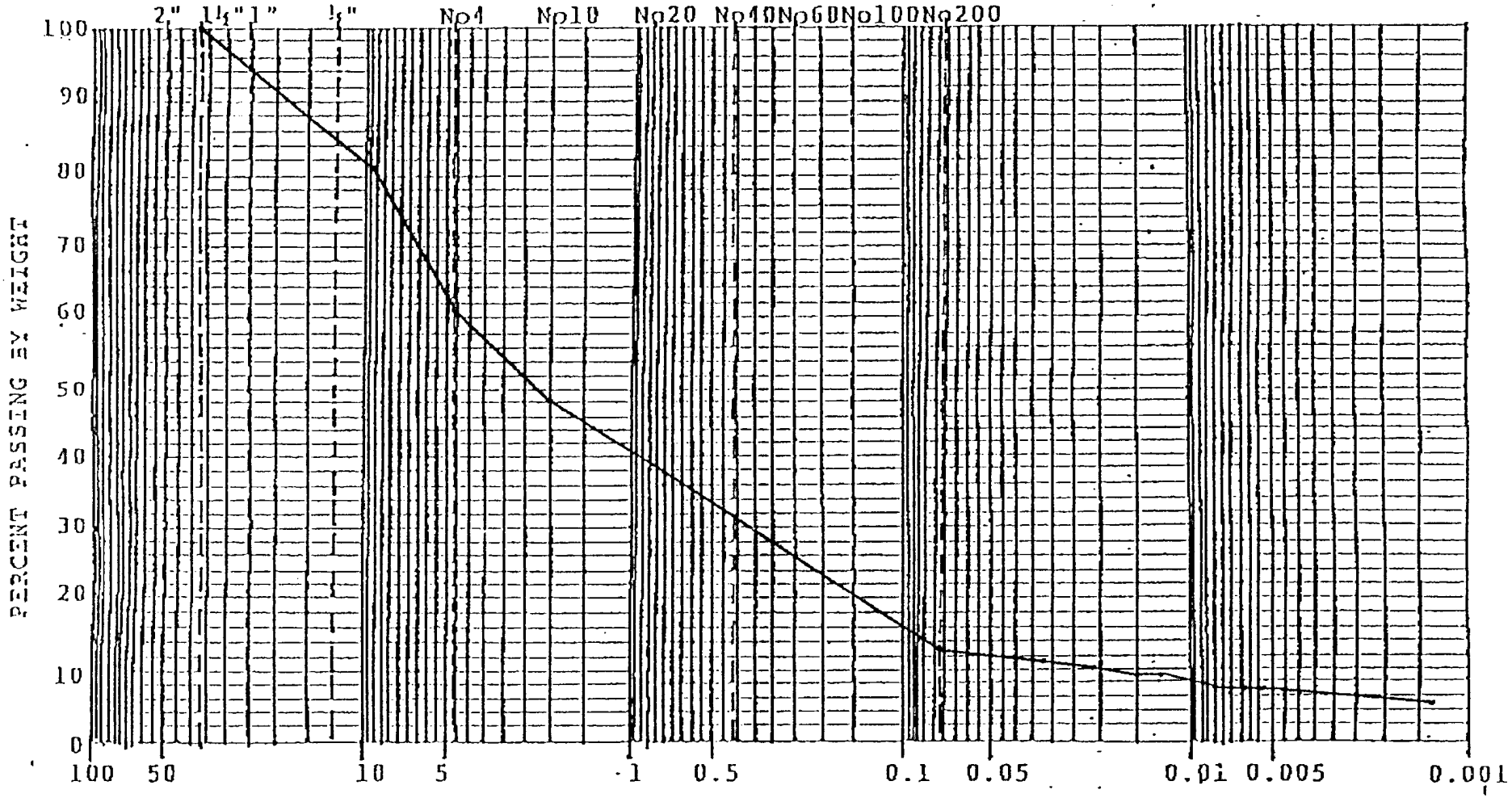
COBBLES	COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES	
	GRAVEL		SAND			FINES		

SAMPLE DESCRIPTION: Engineering Science

LABORATORY NUMBER: 9303026-4A

SAND	47%
SILT	8%
CLAY	6%

U.S. STANDARD SIEVE SIZES



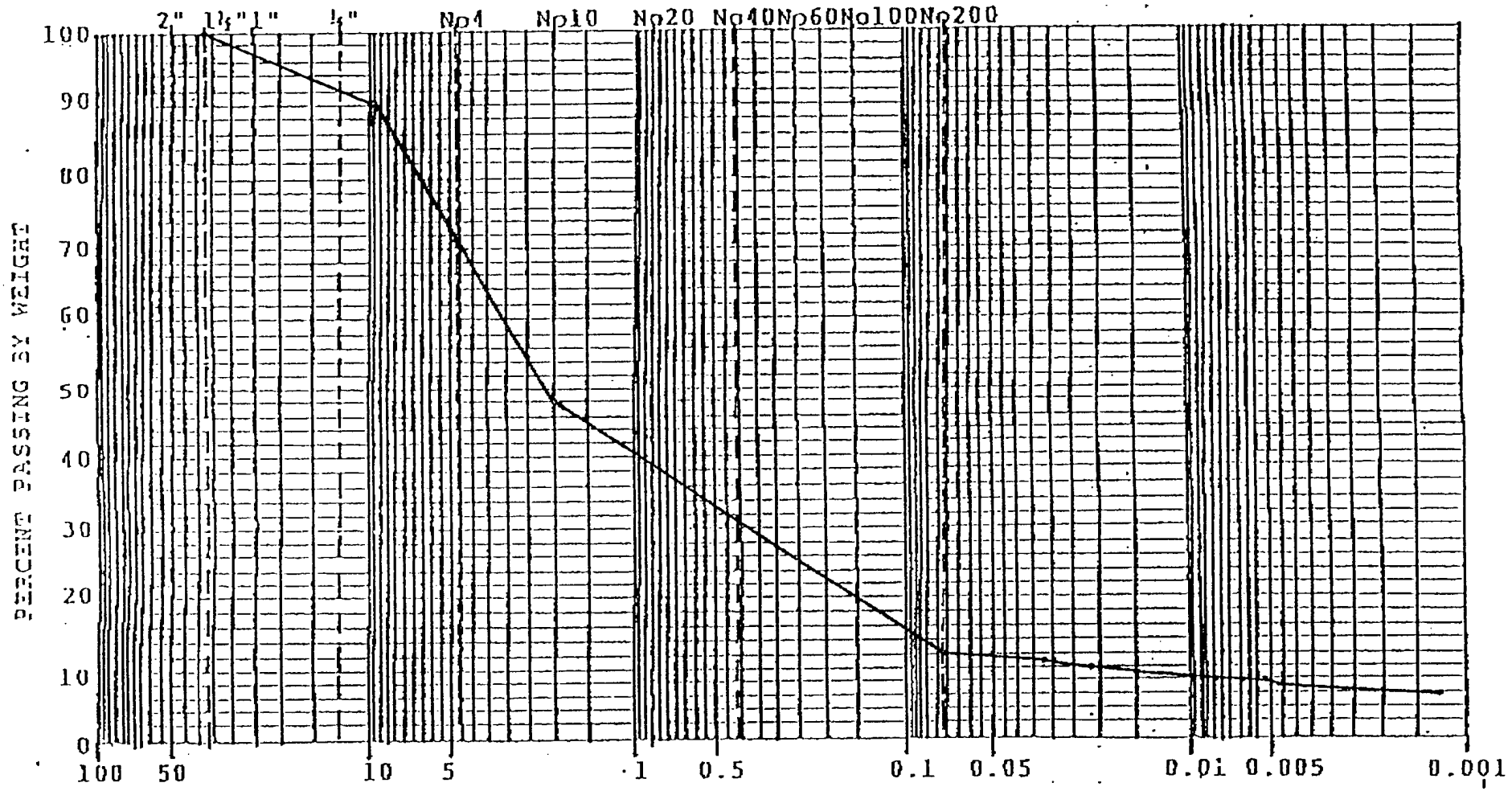
COBBLES	COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES	
	GRAVEL		SAND			FINES		

SAMPLE DESCRIPTION: Engineering Science

LABORATORY NUMBER: 9303026-5A

SILT	6%
CLAY	6%

U.S. STANDARD SIEVE SIZES



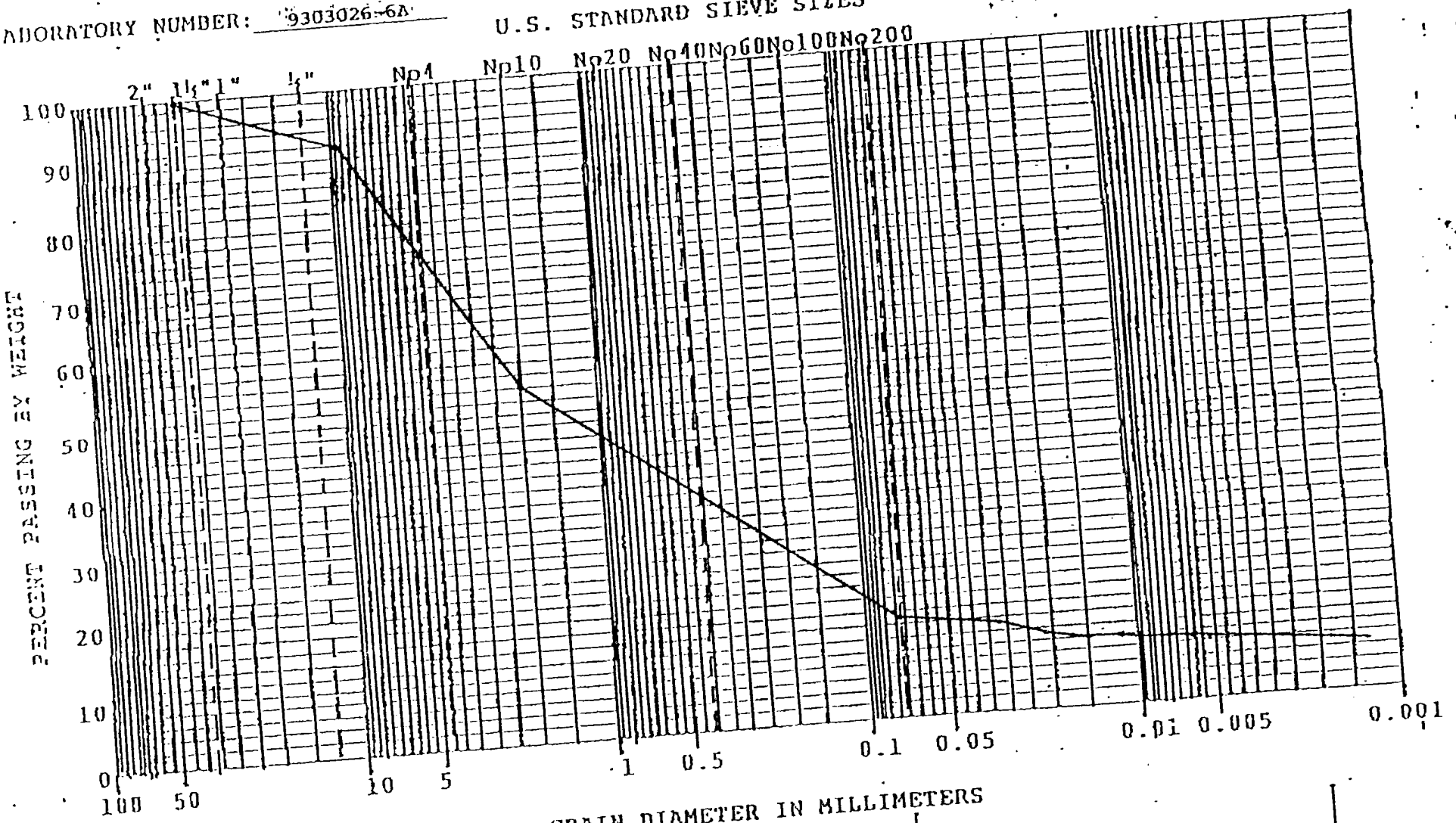
COBBLES	COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES		CLAY SIZES
	GRAVEL		SAND			FINES		

SAMPLE DESCRIPTION: Engineering Science

LABORATORY NUMBER: 9303026-6A

SILT	
CLAY	7%

U.S. STANDARD SIEVE SIZES



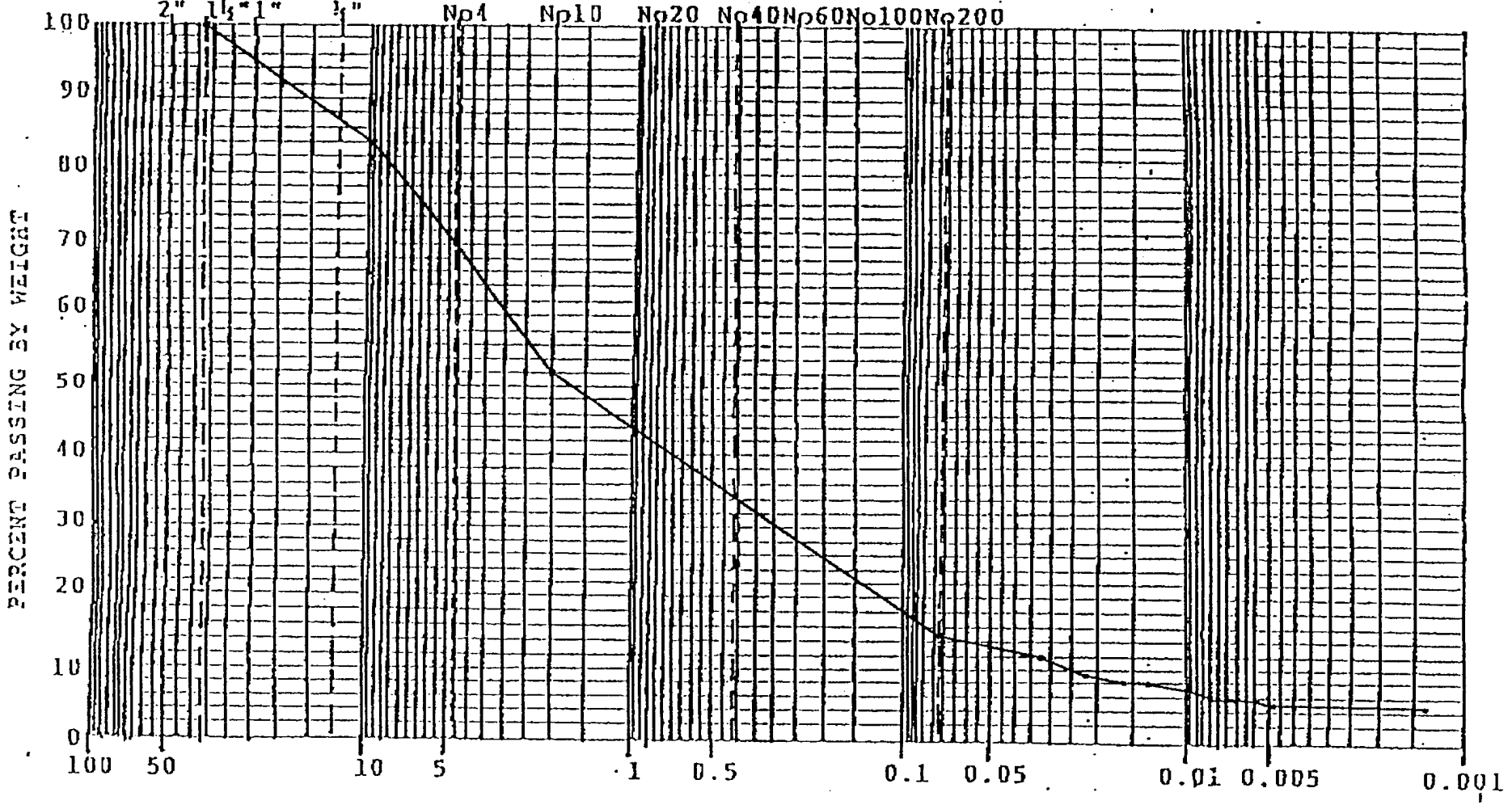
	COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES
COBBLES	GRAVEL		SAND			FINES	

SAMPLE DESCRIPTION: Engineering Science

SAND	84⅛
SILT	11⅛
CLAY	5⅜

LABORATORY NUMBER: 9303026 7A + 8A composite

U.S. STANDARD SIEVE SIZES



COBBLES	COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES
	GRAVEL		SAND			FINES	

ENGINEERING-SCIENCE

CHAIN OF CUSTODY RECORD FOR WATER SAMPLES

ES JOB NO. | PROJECT NAME/LOCATION: W.O. 4840 | PRESERVATIVES REQUIRED | SEQUOIA LAB

ELD CONTACT: R. Claiborne | ANALYSES REQUIRED

AMPLERS NAMES & SIGNATURES

DATE	TIME	FIELD SAMPLE IDENTIFIER	TKN	T. Phosphorous	Chloride (Class)	Particle Size by Sieve & Hydrometer								REMARKS
2/3	1100	J1-VW1-4.5'-5.0	X	X	X	4840-3C-				9303026-01				16-02-Jan (26 ?)
	↓	J1-VW1-5'-5.5	X	X	X	-4C-							-02	Report To:
	1400	J2-VW-4.5'-5.0	X	X	X	-5C-							-03	Tom Paulson ESBL
	↓	J2-VW-5.0'-5.5'	X	X	X	-6C-							-04	Report Blank MS/MSD Recvy
	1050	J3-VW-4.0'-4.5'	X	X	X	-7C-							-05	of Calibration
↓	↓	J3-VW-4.5-5.0'	X	X	X	-8C-							-06	Dry Wt. Basis
	~~0830~~	~~J-BG~~ RVK 2/12/93												USE MDL FOR REPORTING
	0830	J-BG-5.5'-6.0'	X	X	X	-9B }	Tin Tubes						-07	LIMITS.
	↓	J-BG-6'-6.5'	X	X	X	-10B }							-08	Composite

ELD CUSTODY RELINQUISHED BY: R. Claiborne DATE: 2/12/93 TIME: 1120

IPPED VIA: AIRBILL # ON RECEIPT: CUSTODY SEALS? _____; TEMP: _____ °C

CEIVED FOR LABORATORY BY: [signature] DATE: 3/1/93 TIME: 1150

BATTELLE
505 KING AVE,
COLUMBUS, OH
43201

DHL

~~AIR TOXICS LTD.~~
AN ENVIRONMENTAL ANALYTICAL LABORATORY

~~11325 SUNRISE GOLD CIRCLE, SUITE 'E'~~
~~RANCHO CORDOVA, CA 95742~~
~~(916) 638-9892 • FAX (916) 638-9917~~

CHAIN OF CUSTODY RECORD

Page 1 of 1

PROJECT # Johnston Atoll PO # Job No 248.01 COLLECTED BY (Signature) J. Kittel / G. Headington
REMARKS Send Data to JEFF Kittel at BATTELLE. (614) 424-6122
FAX (614) 424-3667

FIELD SAMPLE I.D.#	SAMPLING MEDIA (Tenax, Canister etc.)	DATE/TIME	ANALYSIS	~~VAC./PRESSURE~~	~~LAB I.D. #~~
J-BG-4.5'-5.0'	Soil - Split Spoon	21 FEB 93 / 0820	BTEX / TPH		
J-BG-5.0'-5.5'	Soil - Split Spoon	21 FEB 93 / 0820	BTEX / TPH		
J1-VW-4.5'-5.0'	Soil - Split Spoon / 2-500cc	21 FEB 93 / 1100	BTEX / TPH / Alkalinity, TP, TKN, Fe, sieve		pH + moist
J1-VW1-5'-5.5'	Soil S.S. (2)-500cc g/ASS	21 FEB 93 / 1100	BTEX / TPH / Alkalinity, TP, TKN, Fe, sieve		pH
J2-VW-4.5'-5.0	Soil S.S. (2) 500cc g/ASS	21 FEB 93 / 1400	BTEX / TPH / Alkalinity, TP, TKN, Fe, Sieve		pH
J2-VW-5.0'-5.5'	Soil SS. / (2) 500cc g/ASS	21 FEB 93 / 1400	BTEX / TPH / Alkalinity, TP, TKN, Fe, sieve		pH
J3-VW-4.0'-4.5'	Soil SS. / (2) 500 cc g/ASS	23 FEB 93 / 1050	BTEX / TPH / Alkalinity, TP, TKN, Fe, sieve		pH
J3-VW-4.5'-5.0'	Soil SS. / (2) 500 cc g/ASS	23 FEB 93 / 1050	BTEX / TPH / Alkalinity, TP, TKN, Fe, sieve		pH
J-BG-5.5'-6.0'	Soil Split Spoon	21 FEB 93 / 0830	Alkalinity, TP, TKN, Fe, sieve		pH
J-BG-6'-6.5'	Soil Split Spoon	21 FEB 93 0830	Alkalinity, TP, TKN, Fe, Sieve		pH

RELINQUISHED BY: DATE/TIME	RECEIVED BY: DATE/TIME	RELINQUISHED BY: DATE/TIME	RECEIVED BY: DATE/TIME
Guy Headington 24 FEB 93	R. Claiborne 2/26/93-1030		02/26/93/0800

LAB USE ONLY

SHIPPER NAME	AIR BILL #	OPENED BY: DATE/TIME	TEMP(°C)	CONDITION
DHL		R. Claiborne 2/26/93-1030	5°C	Good

REMARKS

APPENDIX C

OLD FIRE TRAINING AREA SOIL GAS PERMEABILITY DATA

TABLE C-1. RESULTS OF SOIL GAS PERMEABILITY TEST AT MONITORING POINT J1-MPA

Time (Minutes)	Pressure ("H_2O) by Depth		
	2.5′	4.5′	6.0′
0	0	0	0
1	0.13	0.11	0
2.5	0.125	0.125	0
4	0.125	0.125	0
6	0.125	0.125	0
7.5	0.125	0.125	0
15	0.125	0.125	0
30	0.125	0.12	0
50	0.13	0.13	0

TABLE C-2. RESULTS OF SOIL GAS PERMEABILITY TEST AT MONITORING POINT J1-MPB

Time (Minutes)	Pressure ("H_2O) by Depth		
	2.5′	4.5′	6.0′
0	0	0	0
1	0.07	0.135	0.135
3	0.07	0.125	0.125
4.5	0.07	0.12	0.12
7.5	0.07	0.13	0.1
10	0.065	0.13	0.09
16	0.065	0.125	0.095
30	0.07	0.13	0.098
50	0.075	0.125	0.095

APPENDIX D

OLD FIRE TRAINING AREA IN SITU RESPIRATION TEST DATA

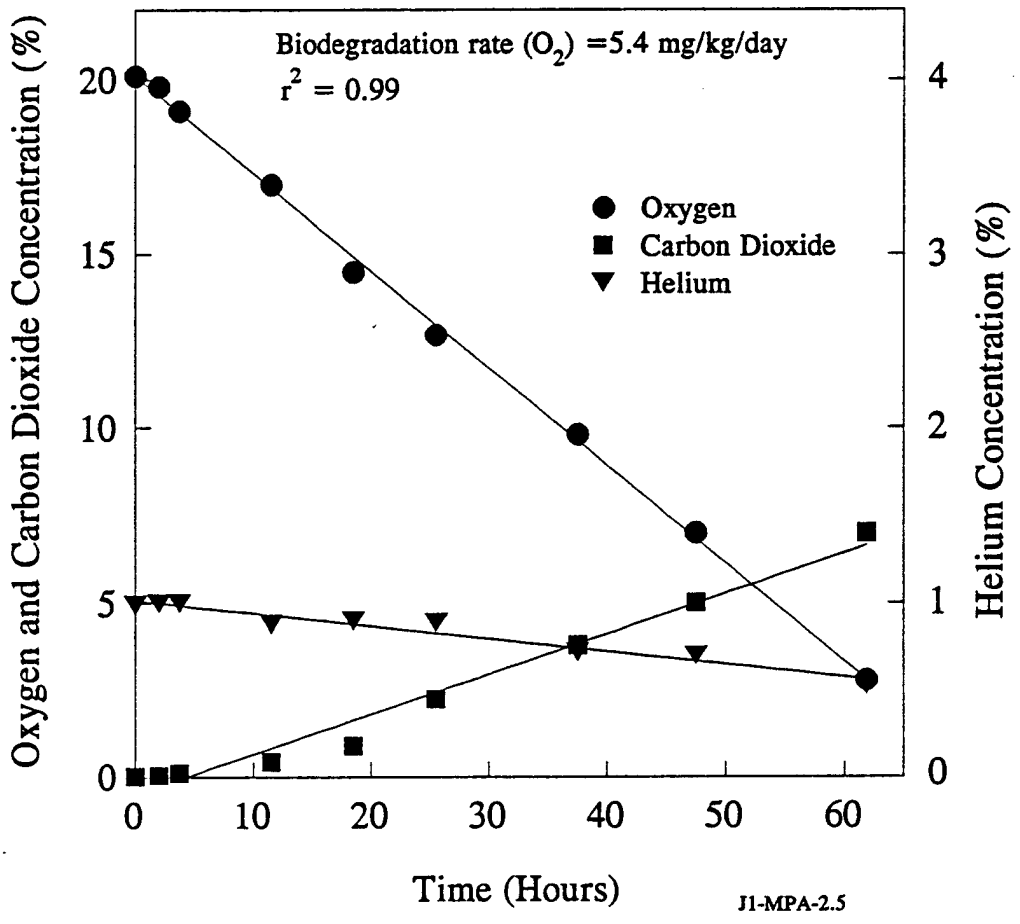


Figure D-1. Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point J1-MPA-2.5′

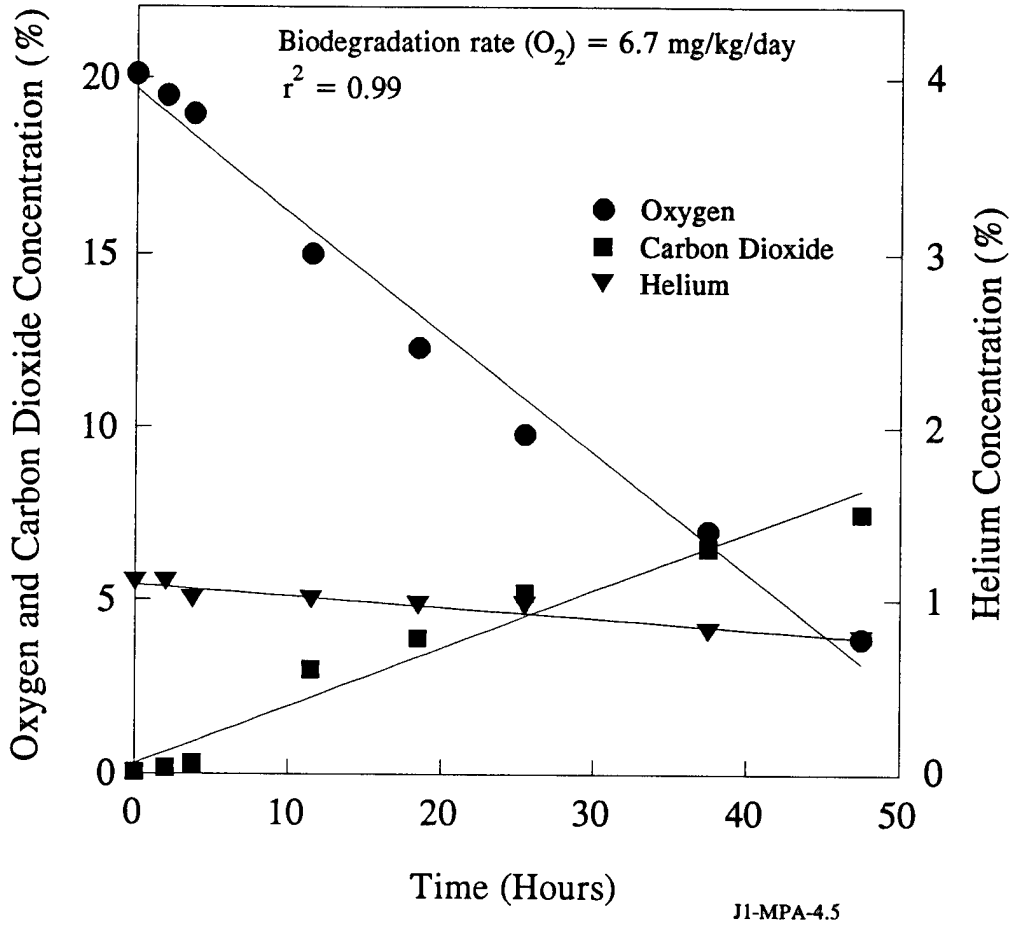


Figure D-2. Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point J1-MPA-4.5′

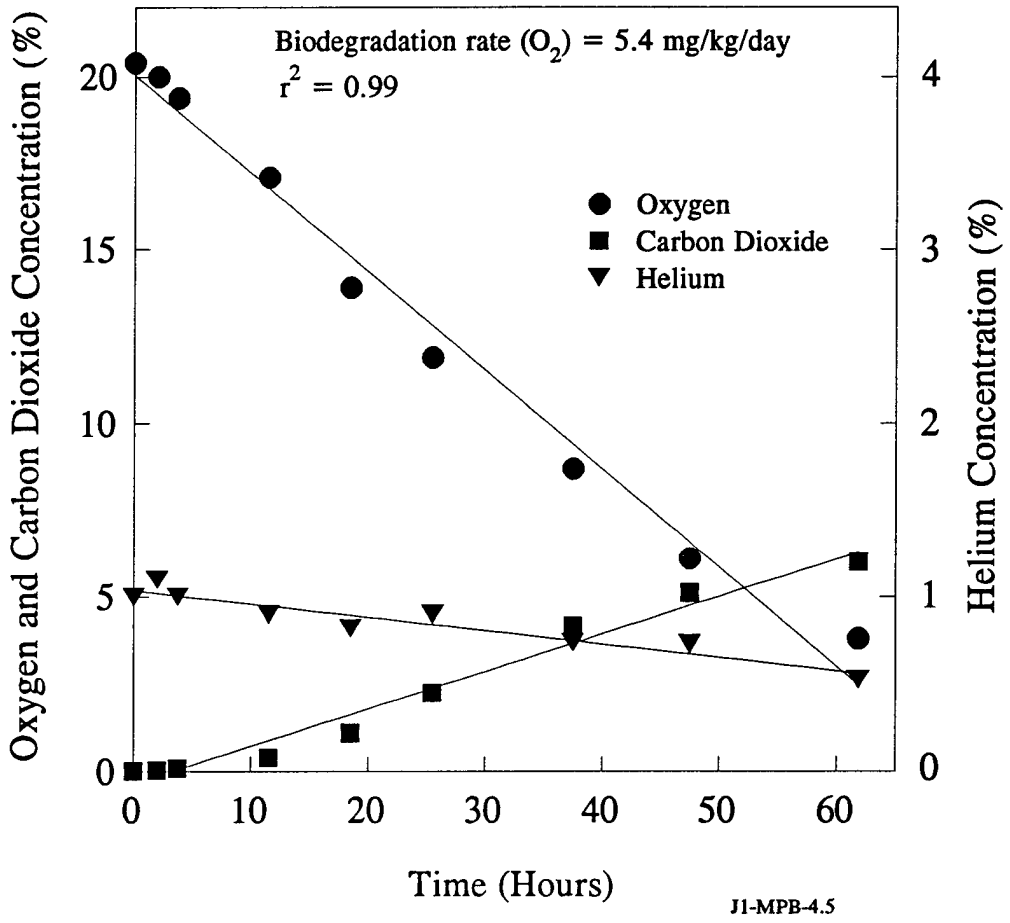


Figure D-3. Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point J1-MPB-4.5′

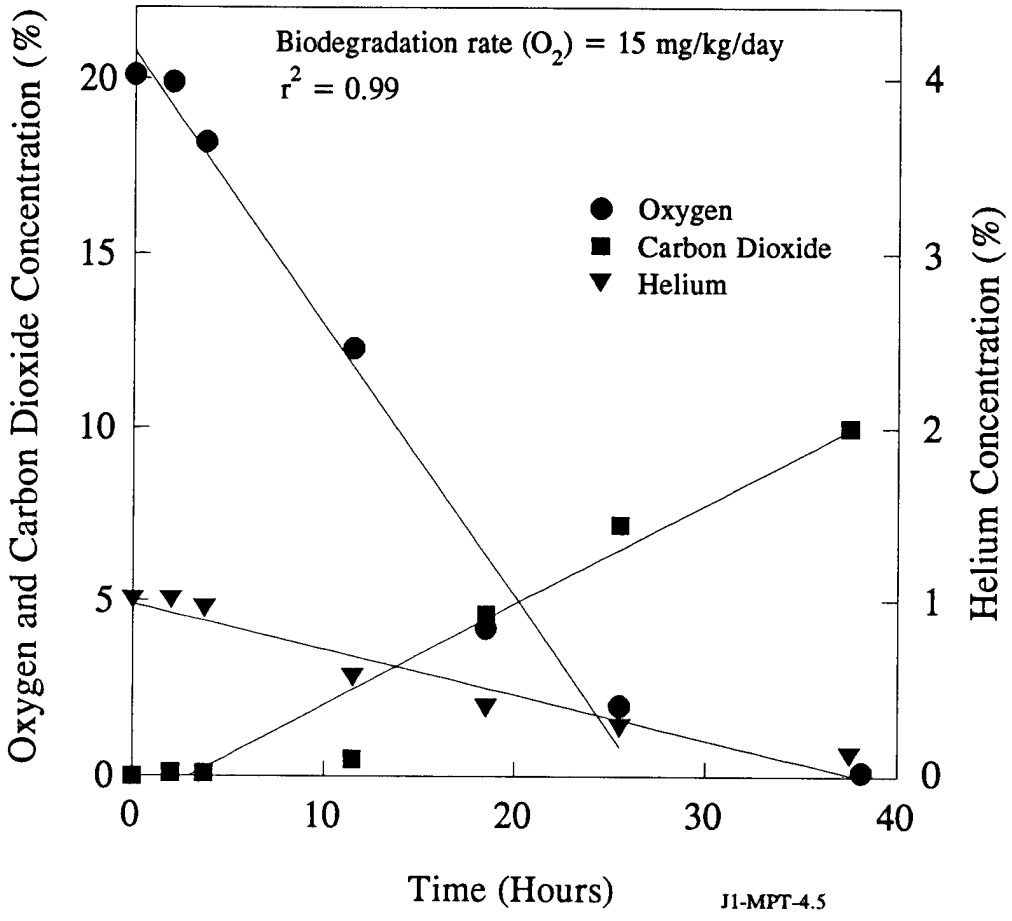


Figure D-4. Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point J1-MPT-4.5′

APPENDIX E

FORMER POL TANK FARM SOIL GAS PERMEABILITY DATA

TABLE E-1. RESULTS OF SOIL GAS PERMEABILITY TEST AT MONITORING POINT J2-MPA

Time (Minutes)	Pressure ("H_2O) by Depth	
	2.5′	4.5′
0	0	0
1	0.56	0.55
3	0.56	0.56
5	0.57	0.57
10	0.57	0.57
20	0.56	0.56
50	0.56	0.56
150	0.55	0.55

TABLE E-2. RESULTS OF SOIL GAS PERMEABILITY TEST AT MONITORING POINT J2-MPB[1]

Time (Minutes)	Pressure ("H_2O) by Depth
	4.5′
0	0
1	0.48
3	0.47
5	0.47
10	0.48
20	0.47
50	0.47
150	0.45

[1] Monitoring point J2-MPB-2.5′ was plugged.

TABLE E-3. RESULTS OF SOIL GAS PERMEABILITY TEST AT MONITORING POINT J2-MPC

Time (Minutes)	Pressure ("H_2O) by Depth	
	2.5′	4.5′
0	0	0
2	0.09	0.08
4	0.09	0.09
6	0.09	0.085
11	0.09	0.085
20	0.-85	0.085
50	0.085	0.08
150	0.08	0.08

APPENDIX F

FORMER POL TANK FARM IN SITU RESPIRATION TEST DATA

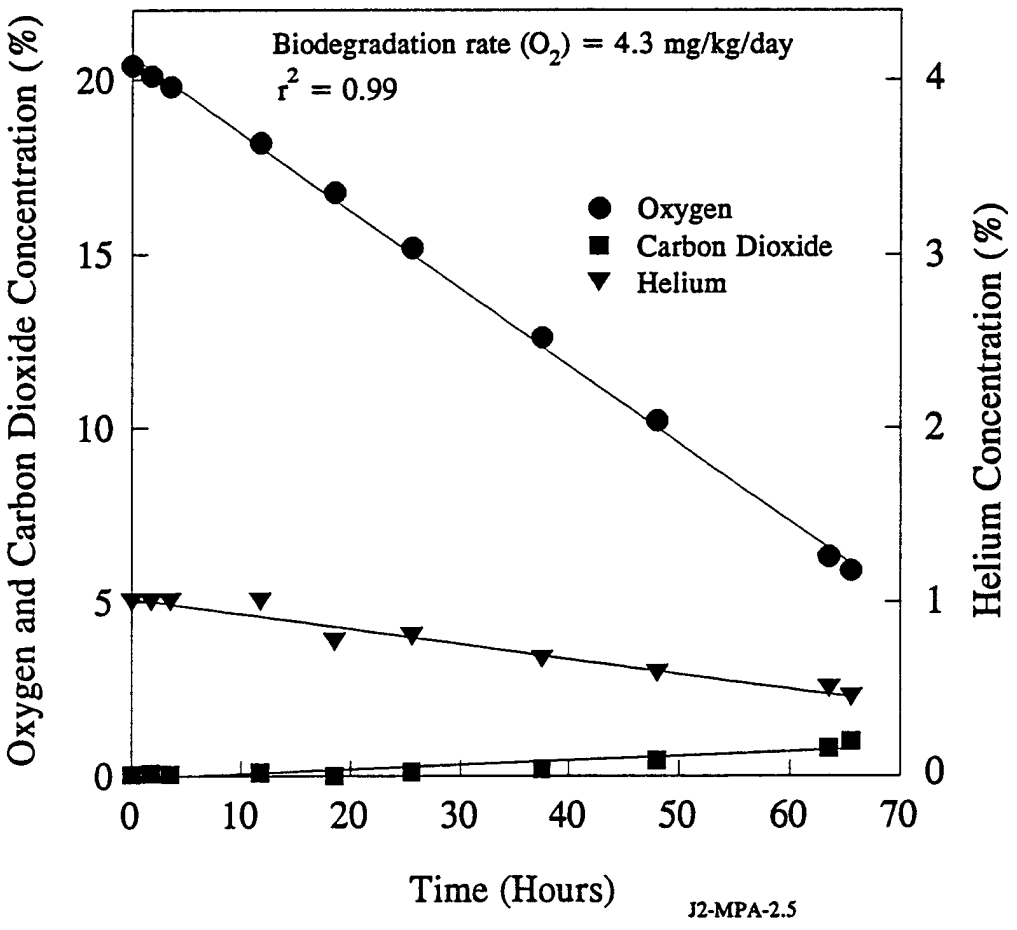


Figure F-1. **Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point J2-MPA-2.5′**

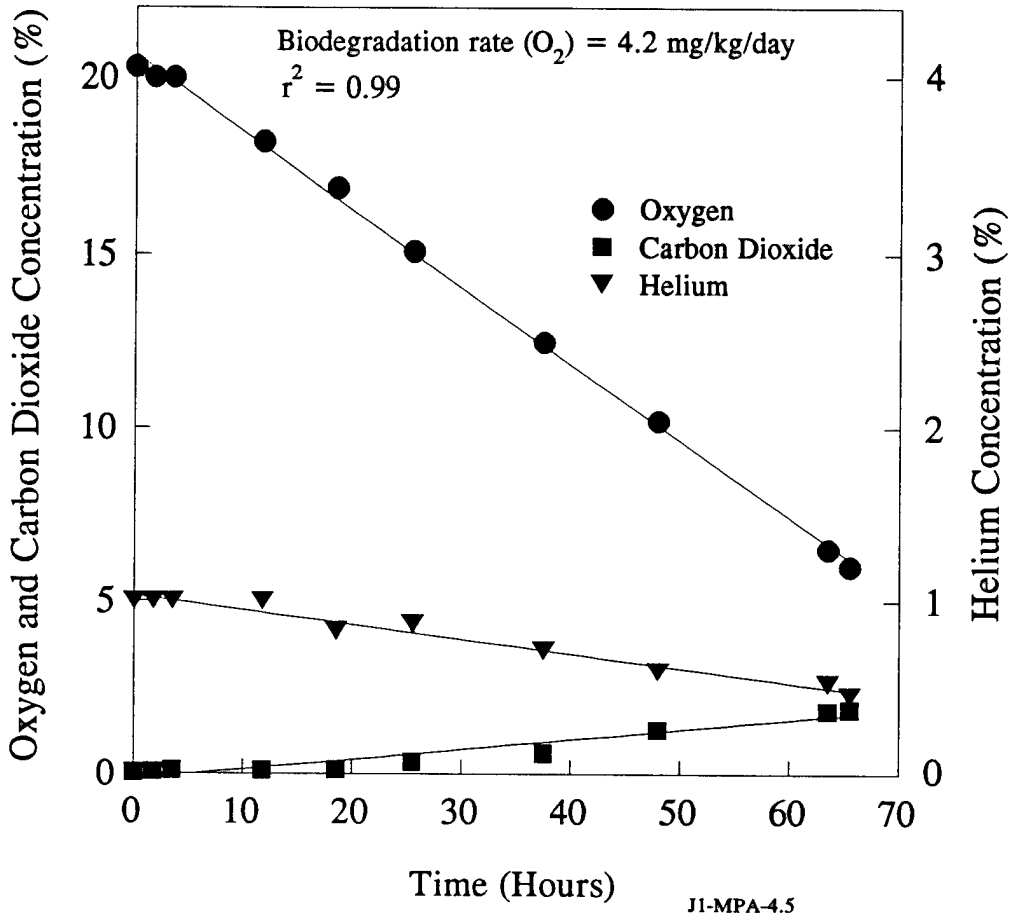


Figure F-2. **Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point J2-MPA-4.5′**

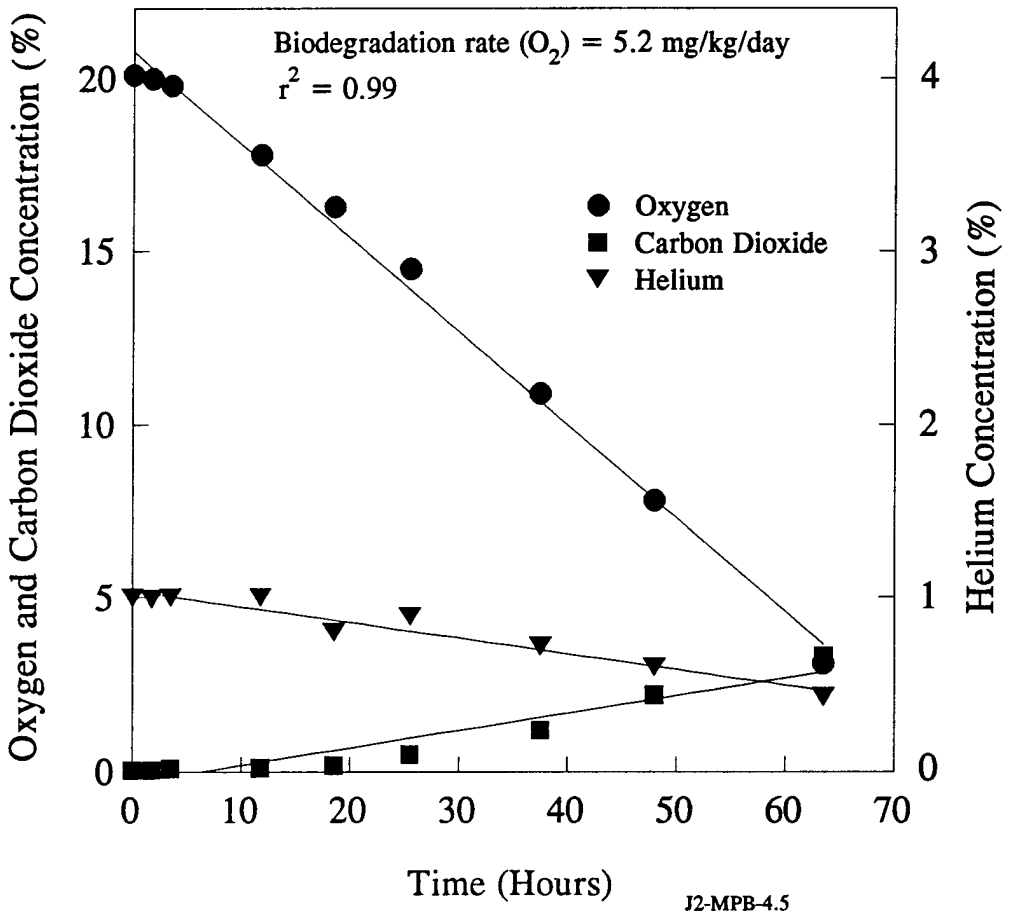


Figure F-3. **Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point J2-MPB-4.5′**

APPENDIX G

STORAGE TANKS 260 AND 261 SITE SOIL GAS PERMEABILITY DATA

TABLE G-1. RESULTS OF SOIL GAS PERMEABILITY TEST AT MONITORING POINT J3-MPA[1]

Time (Minutes)	Pressure ("H_2O) by Depth
	2.5′
0	0
2	0.6
4	0.6
6	0.6
8	0.6
10	0.6
12	0.6
15	0.6
20	0.6
30	0.6
60	0.55

[1] Monitoring Point J3-MPA-4.5′ was plugged.

TABLE G-2. RESULTS OF SOIL GAS PERMEABILITY TEST AT MONITORING POINT J3-MPB

Time (Minutes)	Pressure ("H_2O) by Depth	
	2.5′	4.5′
0	0	0
2	0.240	0.255
4	0.245	0.255
6	0.230	0.255
8	0.230	0.255
10	0.230	0.250
12	0.225	0.255
15	0.19	0.235
20	0.195	0.255
30	0.21	0.250

TABLE G-3. RESULTS OF SOIL GAS PERMEABILITY TEST AT MONITORING POINT J3-MPC

Time (Minutes)	Pressure ("H_2O) by Depth	
	2.5′	4.5′
0	0	0
2	0	0
4	0	0
6	0.05	0.05
8	0.1	0.1
10	0.1	0.1
12	0.1	0.1
15	0.1	0.1
20	0.1	0.09
30	0.09	0.09
60	0.09	0.09

APPENDIX H

STORAGE TANKS 260 AND 261 SITE IN SITU RESPIRATION TEST DATA

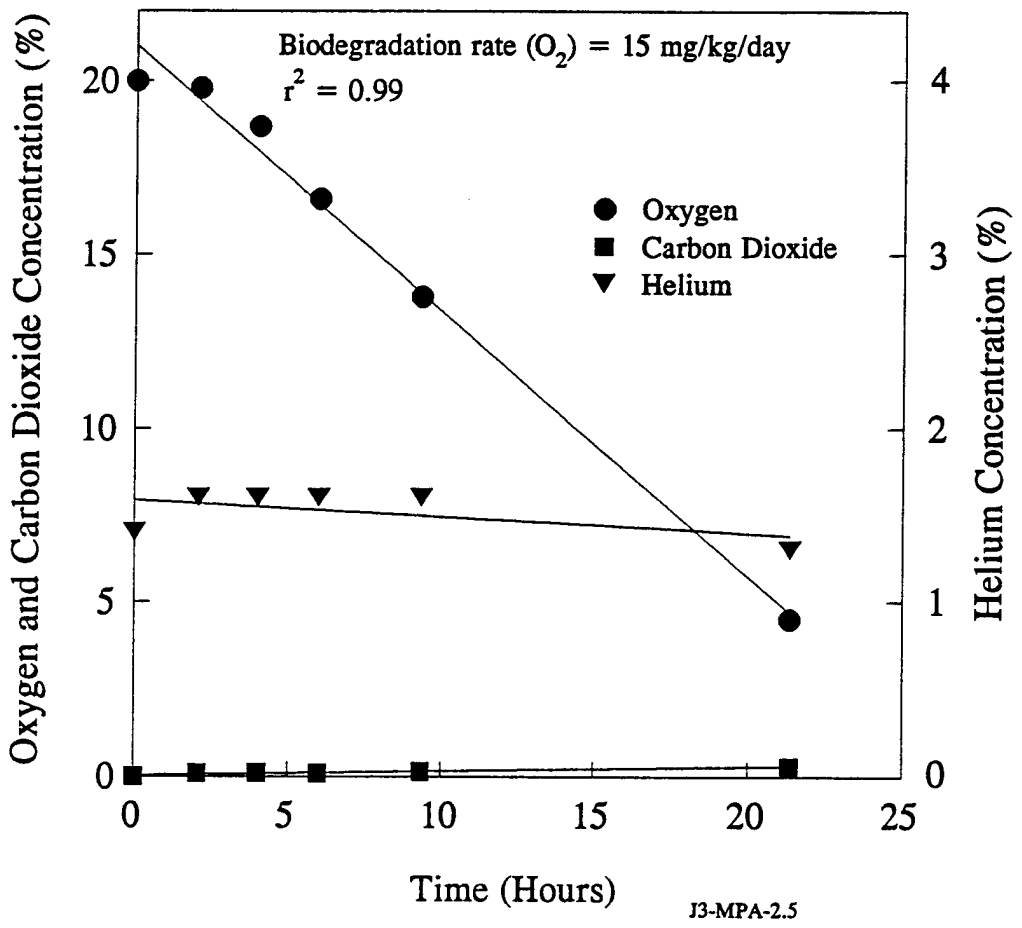


Figure H-1. **Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point J3-MPA-2.5′**

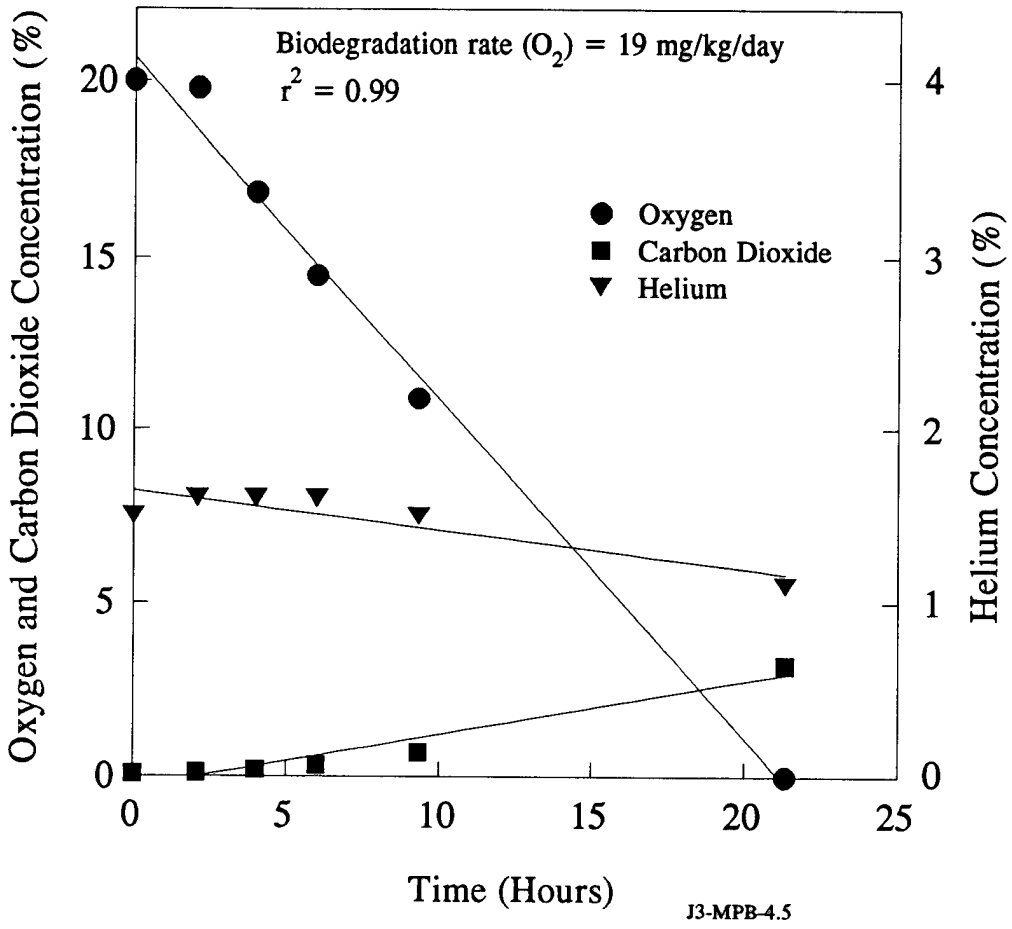


Figure H-2. **Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point J3-MPB-4.5′**

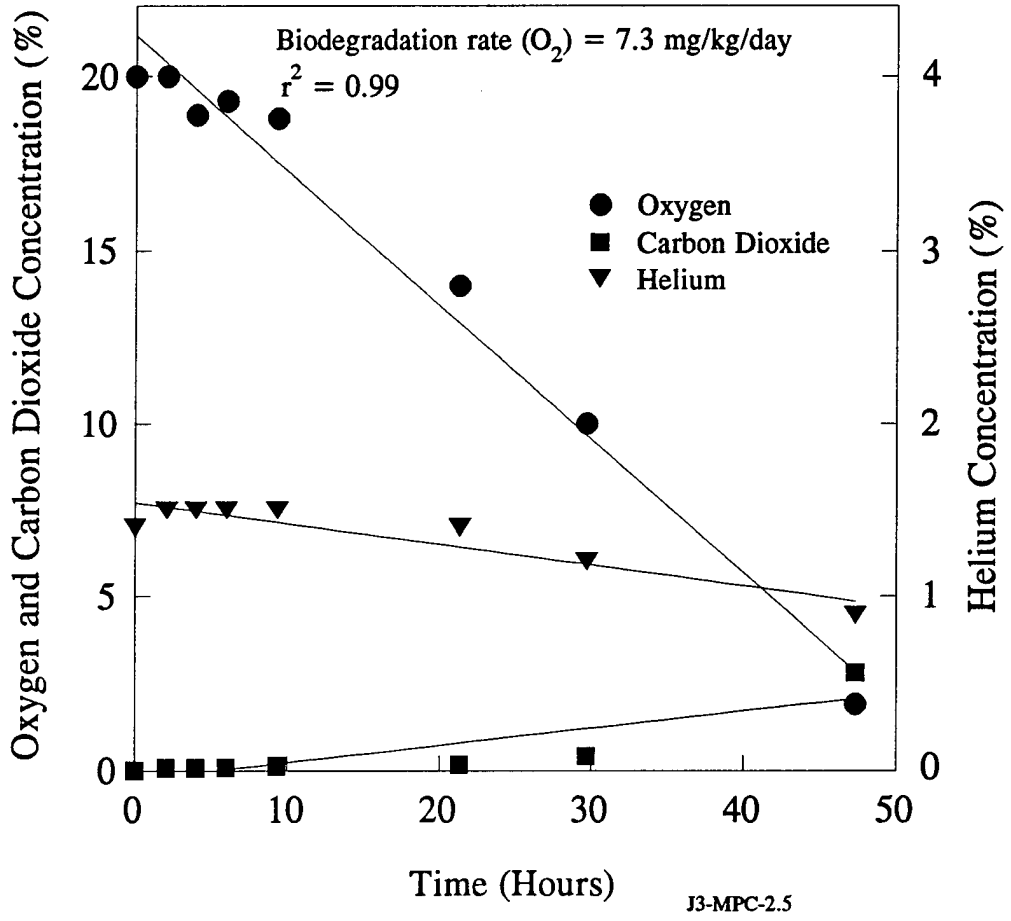


Figure H-3. **Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point J3-MPC-2.5′**

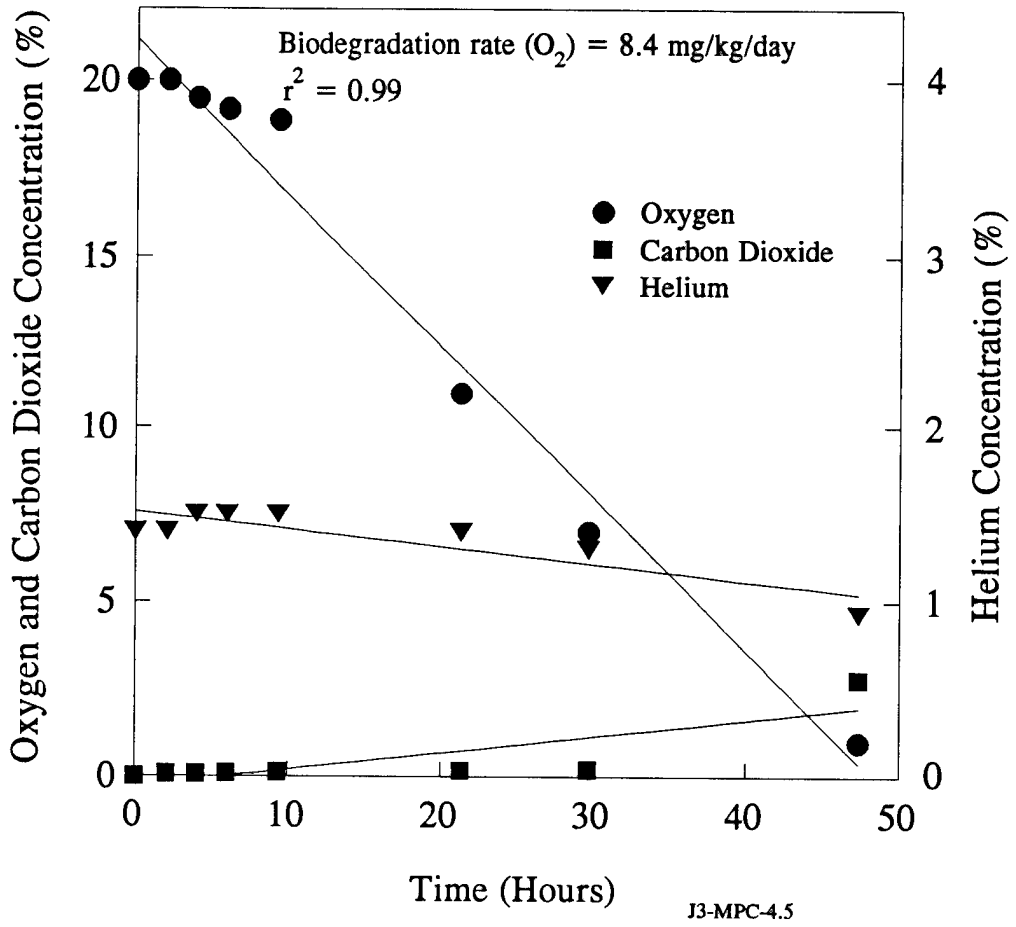


Figure H-4. **Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point J3-MPC-4.5′**